Compressed Air Magazine

NOVEMBER 1943

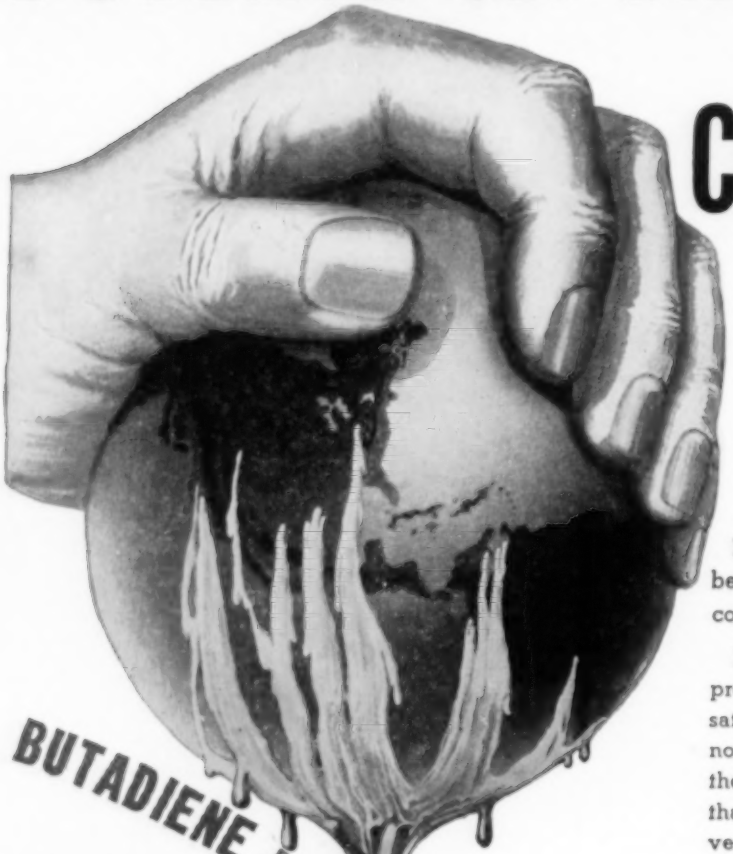
SEABEE

His job is construction, but he can handle a rifle, too.

VOLUME 48 • NUMBER 11

NEW YORK • LONDON

PUTTING ON THE PRESSURE *with* COMPRESSORS



BUTADIENE FOR SYNTHETIC RUBBER
AVIATION GASOLINE
LUBRICATING OILS
TOLUOL FOR TNT
SYNTHETIC AMMONIA FOR POWDER
FUEL OIL AND GAS
FORMALDEHYDE FOR PLASTICS
METHANE FOR ANTIFREEZES
SYNTHETICS

Enormous quantities of raw gases and oils are being squeezed from the bowels of the earth and converted into many of the most vital war materials.

If you are a petroleum or chemical engineer or production man, you know the story, but it is a satisfaction to the rest of us to know that you are not bleeding old Mother Earth to death . . . that there will be enough left for future generations, so that they, too, can share the comforts and conveniences made possible by petroleum products.

By repressuring, you are prolonging the life of hundreds of fields for years to come; by recycling in distillate fields, you are taking gases that have already yielded much gasoline and are returning them under high pressures to the sands for future use.

By constantly improving production and refining methods, you are making every well, every barrel of oil, and every cubic foot of gas yield a greater quantity of usable product. You are making them yield higher-quality products in ever-increasing variety.

The heart of each of these phases is the compressor . . . one of the machines that must be able to operate continuously 24 hours a day, day after day.

And the name *Ingersoll-Rand* on so many of these machines, as well as their records of performance, will undoubtedly be the signpost to buyers in post-war expansion of this essential industry. In the meantime our engineers will be glad to co-operate in helping to solve your problems.

Ingersoll-Rand

11 Broadway, New York, N. Y.

6-340

COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

HOW STAYNEW FILTERS HELP AMERICA AT WAR

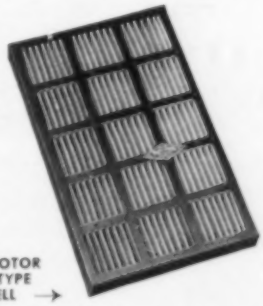
THROUGHOUT American industry, Staynew Filters increase production, reduce maintenance. More guns, planes, tanks, ships, shells, trucks, and war materials of every kind are produced and moved faster to the fighting fronts because Staynew Filters are on the job.

At the fighting fronts, Staynew Filters add to the deadly efficiency of American weapons. Many a U. S. fighting man today owes his very life to the greater fire-power, speed, efficiency, or reliability of Staynew-equipped instruments of war.

After Victory, Staynew Filters will again help peacetime industry produce better, cheaper, faster.

Partial List of Staynew Filters and Their Direct Application to America's War Effort

STAYNEW INTAKE FILTERS help maintain maximum performance of airplane, tank, truck, and marine engines by preventing the intake of abrasive dust.



PROTECTOMOTOR AIRCRAFT-TYPE FILTER CELL →

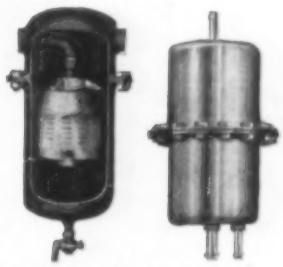
CIRCULAR TYPE AIR INTAKE FILTER

STAYNEW INTAKE FILTERS (Aircraft-type) help maintain a sufficient supply of clean air to aircraft carburetors and engines.

MODEL CPHLS LIQUID LINE FILTER

STAYNEW LIQUID LINE FILTERS add to long life and reliability of internal combustion engines for airplanes, tanks, trucks, and naval vessels by removal of gritty particles and carbon from fuel and lubricating oils. These filters speed war production by removing foreign matter from coolant oils; they guarantee clean water in the field for photo-processing; they are capable of handling algae-bearing water.

A B



A—Model CPH Oil Vapor Arrestor.
B—Model CP Aircraft-type Oil Vapor Arrestor.

STAYNEW OIL VAPOR ARRESTORS prevent oil from crankcase breathers reaching blades of engine turbo-chargers; also prevent oil from the discharge of rotary or other types of compressors damaging or fouling accessory apparatus and control mechanisms.

Automatic Type Ventilation Filter

STAYNEW FILTERS for building ventilation, including automatic and dry panel types, are contributing everywhere to the continuity of service of both men and machines.

BUILDING AIR-SUPPLY FILTER

Have You A Filter Problem?

The broad experience of Staynew engineers is proving invaluable in solving war industry problems. This experience, product of more than 22 years of exclusive filter manufacturing, is yours for the asking.

OVER ONE MILLION STAYNEW FILTERS PLACED IN SERVICE

STAYNEW FILTER CORP.

PROTECTOMOTOR AIR FILTERS

"Filter Headquarters"

7 FILTER PK., ROCHESTER, N. Y.

What do you do when a motor quits?

Well, frankly, you're in a jam.

You should, of course, take care of motors *before* they quit, by giving them the *little* maintenance so necessary to keep them on the job.

For example, let's consider Small Motors . . . those tiny, work-til-they-drop fellows who run your pumps, fans, appliances, and so forth. How long has it been since you gave them a little care?

It's so easy to keep your Small Motors in A-1 shape, happy at their job. Just be on the alert for their common enemies . . . friction, dust, moisture, vibration, overheating, noise.

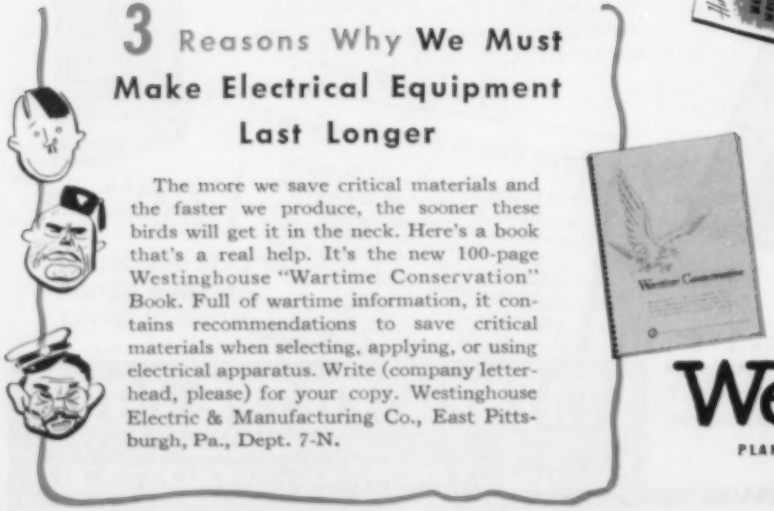
If your Small Motor is already suffering from "ill-motor health", diagnose the symptoms and get it running again. Probably it's only suffering from a very common ailment.

We have just prepared a new Small Motor Maintenance booklet. It tells you how to protect your motors from their enemies, what to do when they attack. This new booklet is so chock-full of sound information that you will value it from the very moment you receive it.

For example, what would you do if your Small Motor failed to start? There are 13 possible "reasons why" and this new booklet tells what to do about each. You'll find it easy to understand; profusely illustrated; complete with maintenance details.

Keep those Small Motors on the job—our country needs them! Let us send a free copy of this booklet for each maintenance man in your factory or shop. No obligation. Just tell us how many you need. Ask for B-3215. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

J-90473


3 Reasons Why We Must Make Electrical Equipment Last Longer
The more we save critical materials and the faster we produce, the sooner these birds will get it in the neck. Here's a book that's a real help. It's the new 100-page Westinghouse "Wartime Conservation" Book. Full of wartime information, it contains recommendations to save critical materials when selecting, applying, or using electrical apparatus. Write (company letterhead, please) for your copy. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., Dept. 7-N.
Wartime Conservation

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

small motors

IN JUST THREE HOURS... two men have hooked up 1,000 feet of ready strung 4-inch line in 20-foot joints. *Victaulic is the fastest known method of coupling pipe.* Its flexibility eliminates the need for accurate aligning of pipe... saving money, saving time, saving man-hours. Self-Aligning Victaulic Couplings give you all these added advantages...

1 **Fast, Self-Aligning permits angular deflection!**

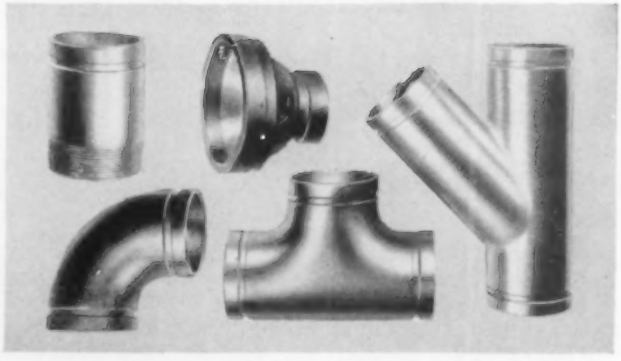
2 **Leak-tight, self-sealing under pressure or vacuum!**

3 **Positive mechanical lock of pipe lengths!**

4 **Every joint is a pipe union!**

5 **Every joint an expansion joint!**

DOLLAR SAVING FEATURES FOR INDUSTRIAL CONSTRUCTION! Installed faster and with less labor than any other method. A small socket wrench is the only tool needed. Victaulic joints are compact, flexible. Provide substantial savings in space and weight. Temporary lines can be salvaged 100 per cent. Maintenance is nil on permanent jobs.



VICTAULIC FULL-FLOW FITTINGS! A new line of redesigned pipe fittings to eliminate undue frictional losses! Engineered with long easy sweeps to reduce the possibility of clogging to an absolute minimum. A real contribution to greater efficiency in conducting fluids and gases in pipe systems.

BUY MORE WAR BONDS!

INDUSTRIAL VICTAULIC

SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

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Available soon for your permanent files . . . a new easy-to-use Victaulic Catalog and Engineering Manual. Reserve your copy now!

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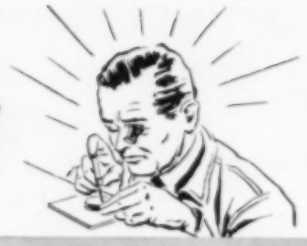
*Address*_____

Mail to nearest address: VICTAULIC COMPANY OF AMERICA, 30 Rockefeller Plaza, New York 20, N. Y.; Victaulic Inc., Los Angeles 14, California; Victaulic Co. of Canada, Ltd., Toronto. 2F

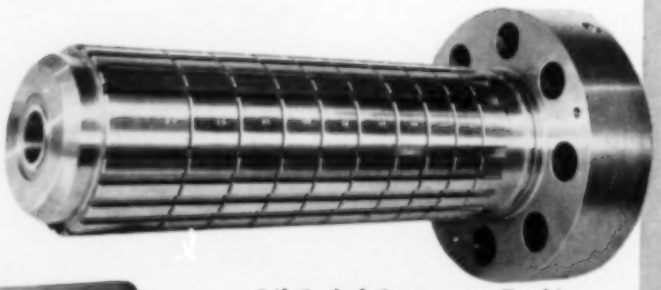
PACKINGS OF WATCHMAKER ACCURACY



Circulator Packing for 5150 lbs. Pressure

Compressor Packing for 5000 lbs. Pressure

Oil Cooled Circulator Packings for 3100 lbs. Pressure



Oil Cooled Compressor Packing for 12,500 lbs. Pressure

All France packings are "built like a watch," but Steel Case Packings, representing the highest degree of our technique and "know how," mean something special to our people. They can remember how many times they "miked" them for size, how carefully each joint was hand-lapped, how they handled each section with "kid gloves" until the whole packing was tenderly boxed and shipped.

High Pressure Steel Case Packing deserves special care and special mention for it is used in synthesis plants on primary compressors or circulators, holding gas pressures up to 15,000 lbs. As shown in the illustrations, there is a great variety. Some are oil cooled. Some have cylinder heads integral with the packing. Outboard circulator packings have a tail rod cover attached.

There are many high pressure designs not shown above, and several hundred packings of these types are now operating without a single failure.

In any case, best results are obtained when we are given the opportunity to work with the engineer designing the compressor on which the packing is used.

If you have a specific problem, we'll be glad to discuss it with you.

★ FRANCE PACKINGS and PISTON RINGS ★

FRANCE MFG. CO.

FRANCE MANUFACTURING COMPANY

Belgrade and Orthodox Streets, Philadelphia, Pa.

The One Constant Ingredient

Every V-Belt made by Dayton Rubber contains one ingredient which never varies. Wartime restrictions can never affect it. It is mixed into every compound of natural or synthetic rubber. It is woven into every inch of fabric, cord or wire destined for Dayton V-Belts.

This constant ingredient is the sum total of Dayton Rubber's 37 years of continuous development, processing and application of rubbers and fabrics of every type. It is the residue of thousands of man-hours of patient research, practical testing and controlled manufacturing ability. This constant ingredient is the technical knowledge and experience that you would naturally expect to find built into every V-Belt by Dayton, the world's largest maker.

So whether the V-Belts you use are made of today's synthetics or tomorrow's "X" materials need not concern you — so long as they bear the name which stands for Technical Excellence over the years.

THE DAYTON RUBBER MFG. CO.
DAYTON 1, OHIO

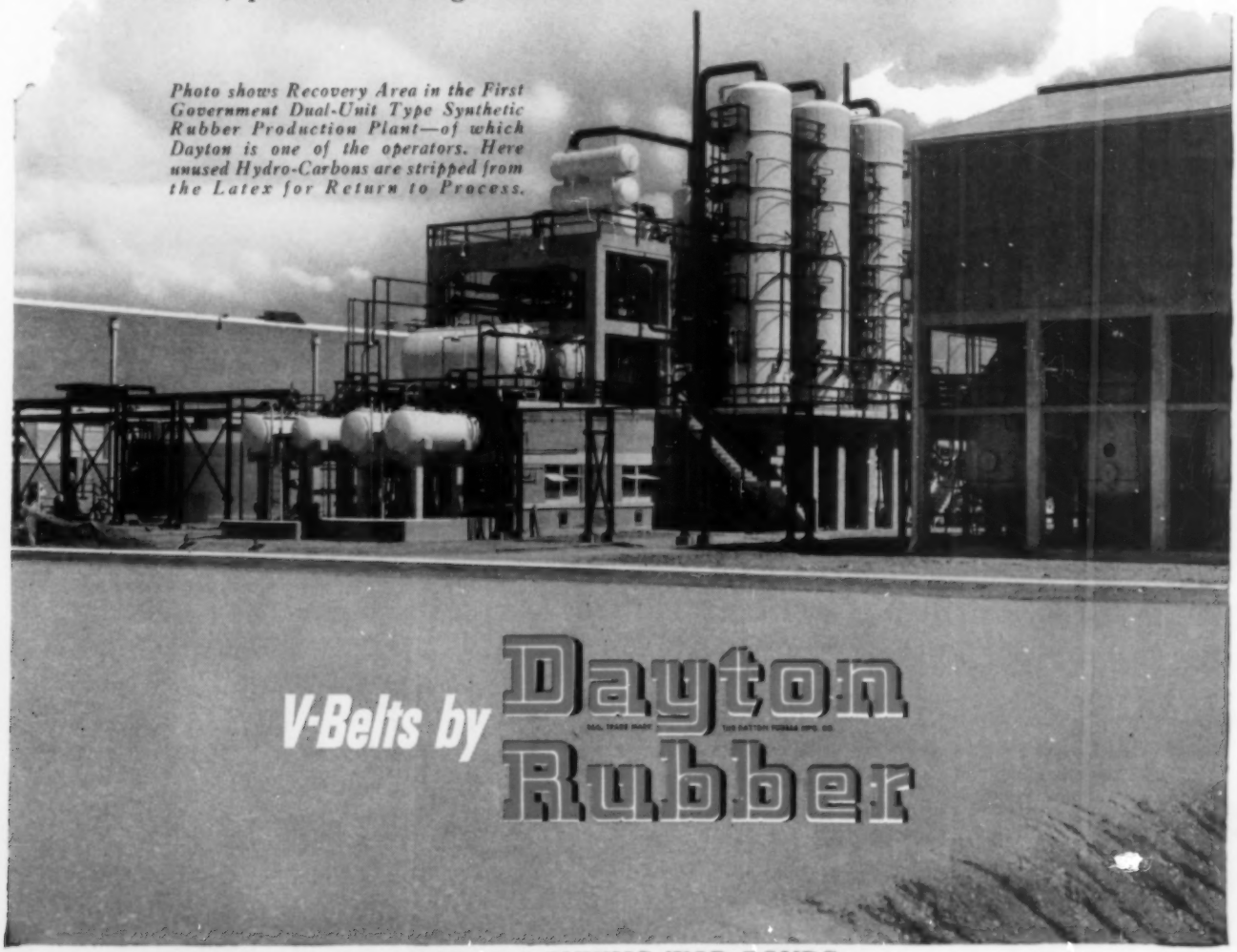


Photo shows Recovery Area in the First Government Dual-Unit Type Synthetic Rubber Production Plant—of which Dayton is one of the operators. Here unused Hydro-Carbons are stripped from the Latex for Return to Process.

KEEP ON BUYING WAR BONDS

DON'T TIE HIS HANDS

with heavy, unwieldy tools

GIVE HIM *Lightweight* AIR TOOLS

He'll Produce More Work With Less Effort

Operators have the desire to produce. Therefore the *tool,* the medium by which their desire and energy is transformed into actual work, becomes the all-important item in final production. This means that you should select the tool that will enable them to convert their maximum physical energy to output with the least fatigue.

Running a hand-held machine, day after day, certainly justifies the choice of a lightweight *air* tool—because the reduction of fatigue is a very important factor in maintaining and increasing production.

Modern *air* tools are as much as 50% lighter in weight than other portable tools of comparable power—as much as 50% smaller in size. Their simplicity of design has made possible these important features without sacrificing durability and safety.

Choose from the complete line of Ingersoll-Rand *air* tools. If you wish, a Service Engineer will gladly call and assist you with your *air* tool problems.

Ingersoll-Rand

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COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

HOW TO SOLVE OPERATING PROBLEMS WITH *Correct Lubrication*

New Type Rock Drill Oil "Fortified" to meet Severe Operating Conditions

GARGOYLE ALMO OIL NO. 3

is a High-Quality Mineral Oil Specially Compounded to give Operators these Benefits:

Rifle bar, nut and other moving parts are guarded from wear under severe loads—such as caused when the drill steel sticks. This protective feature in Gargoyle Almo Oil No. 3 results from the exceptional strength of its oil film.

Wear caused by water washing away the oil film and exposing unlubricated surfaces is minimized. Resistance to the washing action of water is obtained by strong adhesive and tacky properties in the oil.

All internal drill parts are guarded from corrosion—another important benefit provided by this oil's resistance to the washing effect of water.

Piston seal is maintained because cylinder walls are continuously oil-wet despite washing action of water.

Maximum drill speed is assured by the correct body of this oil.

Valve action stays free. Gummy products which stick valves are not formed when this oil is used.

No objectionable odor or eye-burning accompanies the use of this oil.

You get extra assurance of obtaining continuous drill operation . . . at maximum speed ...with minimum stalling—and thus securing maximum production.

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION

CALL IN SOCONY-VACUUM

GARGOYLE Lubricants

SOCONY-VACUUM OIL COMPANY, INC.— Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. White Eagle Div. • Wadhams Div. • Magnolia Petroleum Company • General Petroleum Corporation of California

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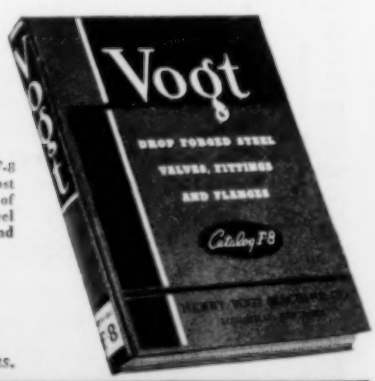
KNOBBED HANDWHEEL*

In high octane gasoline, synthetic rubber, powder, chemical, steam, and hydraulic plants, and marine service — IT identifies Vogt Drop Forged Steel Valves at work for Victory!

TOMORROW — Vogt Valves will again be available to ALL industries where sure and safe control of high pressure and high temperature liquids and gases is a MUST.

**Now available—a new line of malleable iron chain wheels, interchangeable with Vogt knobbed handwheels, for remote control of valves.*

Consult Catalog F-8 for the world's most complete line of Drop Forged Steel Valves, Fittings and Flanges.



Branch Offices: New York, Philadelphia, Cleveland, Chicago, Dallas.

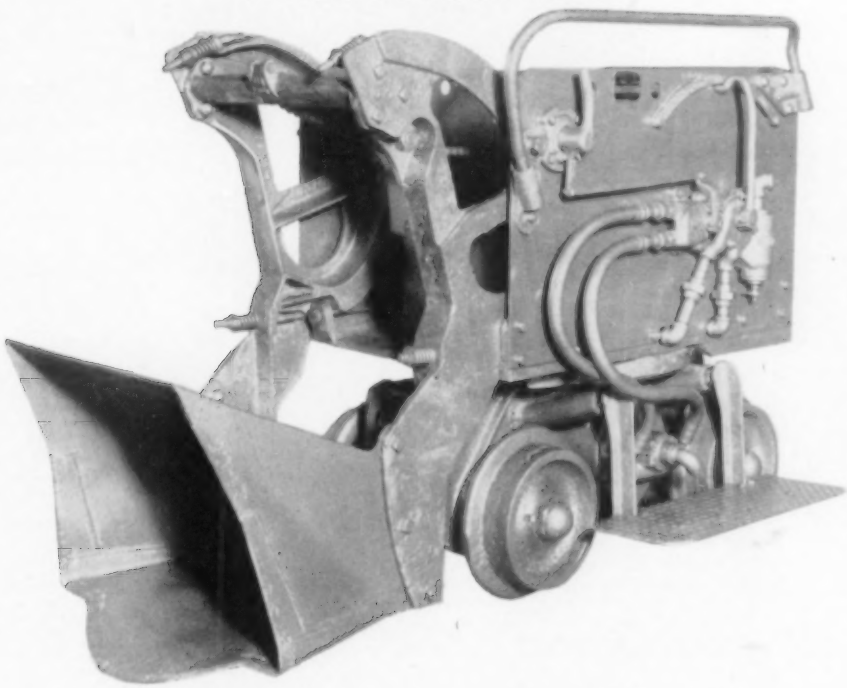
Vogt DROP FORGED STEEL Valves

HENRY VOGT MACHINE CO., LOUISVILLE 10, KENTUCKY

OVER 10 YEARS AGO THE NOW FAMOUS

Eimco "Rocker-Arm" Loading Machine

WAS PATENTED



Since its conception many improvements have been added to insure supremacy in underground loading. To date no substitute has been developed that can match the simple, efficient action and rugged construction of the Eimco Loader as proved by this

FACT

Eimco Loaders have won every competitive test in every mining district in the world.

Don't take our word for it --- Investigate.

Why not buy the Champion!

The inherent superiority of Eimco Loaders has been so thoroughly proved that every machine sold carries a positive money-back guarantee that it will outlast and OUT-PERFORM any other mucking machine of comparable size and type at any air pressure, and under any working condition.

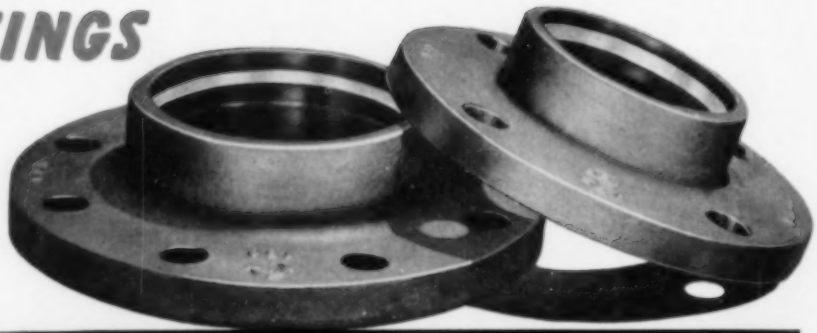
EIMCO

THE EIMCO CORPORATION, SALT LAKE CITY 8, UTAH

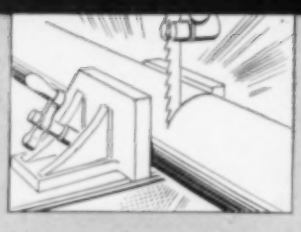
NEW YORK, 120 BROADWAY — SACRAMENTO, 1217 7TH ST.

CHICAGO, 111 W. WASHINGTON ST. — EL PASO, MILLS BUILDING

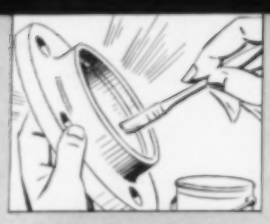
USE WALSEAL FLANGES, FITTINGS AND VALVES!



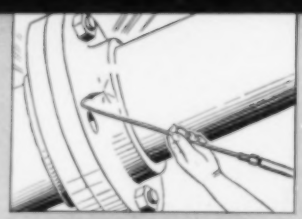
...THE MODERN METHOD OF JOINING COPPER OR BRASS PIPE AND TUBING



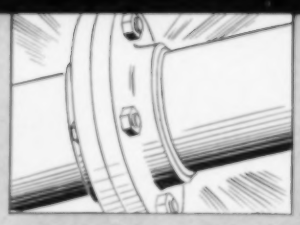
Cut pipe or tubing square, making certain that the pipe is not squeezed out of round or made undersize.



After cleaning flange and pipe carefully, apply flux to the flange recess and to the pipe or tubing.



Expand pipe by heating with the oxyacetylene flame. Next heat section of flange hub; then heat both pipe and flange hub section with wiping motion of torch.



Repeat process on adjacent flange hub and pipe sections. The joint is completed when a fillet of silver brazing alloy shows entirely around pipe at edge of hub.

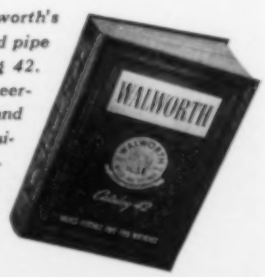
You can save installation time and assure strong, permanent assemblies by using Walseal flanges, fittings and valves. As illustrated in the sketches above, four simple steps connect a flange to the pipe with a silver brazed joint that is tight, leak-proof, and has a corrosion resistance equal to that of the pipe or tubing itself.

Walseal flanges are completely machined, faced, and drilled before brazing so that the assembly is ready to go into the line immediately after brazing. No refacing is required after heating because the relatively low brazing temperatures do not cause any warpage of the flange faces.

Joints made with Walseal flanges, fittings, and valves are not solder joints, but are Silbraz joints. That means that they cannot creep or pull apart under any temperatures to which the pipe or tubing can be safely subjected.

For more complete information on how to install Walseal flanges, fittings, and valves, write for Booklet 84. Address: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

You'll find pertinent information on Walworth's complete line of valves, fittings, pipe, and pipe wrenches in the new Walworth Catalog 42. Included are 78 pages of practical engineering data that simplify valve selection and make piping layouts easier. Write, on business stationery, for your free copy. Address: Walworth Company, 60 East 42nd St., New York 17, N. Y. Department 17.



BOSTON WORKS
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WALWORTH
valves AND fittings

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

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DEVELOPED by the Chemical Warfare Service of our Army Service Forces, these flame throwers use liquid fuel and get their power from compressed hydrogen.

Whether compressing gases or compressing air, operators everywhere are getting better performance by lubricating their compressors *with Texaco*.

Texaco Alcaid, Algol and *Ursa Oils* assure wide-opening, tight-closing valves, free piston rings, open ports, clean air lines, maximum service life between overhauls, fewer repairs and replacements.

A Texaco Lubrication Engineer is freely at your service through more than 2300 Texaco distributing points in the 48 States. The Texas Company, 135 E. 42nd St., New York 17, N. Y.

THEY PREFER TEXACO

★ *More stationary Diesel horsepower in the U. S. is lubricated with Texaco than with any other brand.*

★ *More Diesel horsepower on streamlined trains in the U. S. is lubricated with Texaco than with all other brands combined.*

★ *More locomotives and railroad cars in the U. S. are lubricated with Texaco than with any other brand.*

★ *More revenue airline miles in the U. S. are flown with Texaco than with any other brand.*

★ *More buses, more bus lines and more bus-miles are lubricated with Texaco than with any other brand.*

TEXACO

TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

TUNE IN THE TEXACO STAR THEATRE EVERY SUNDAY NIGHT – CBS ★ HELP WIN THE WAR BY RETURNING EMPTY DRUMS PROMPTLY

Now SEAL both OIL and WATER

NEW JOHN CRANE PLASTIC LEAD SEAL

Insoluble

FOR Heavy duty

PIPE-LINE, REFINERY, MARINE, POWER, CHEMICAL, AVIATION, INDUSTRIAL USES

Temperatures to 600° F. . . . Pressures to 4000 pounds per sq. in.

One "easy-spread" application and your sealing job is done—for sure, for years! John Crane new lead seal is plastic: will not set or seize nor harden under temperature extremes. Joints may be broken after years of service and remade without scraping. Prevents threads, eliminates corrosion. Prevents scoring and galling. Protects threads, clearances. May be applied to cork, paper, asbestos, copper, aluminum, lead, steel . . . John Crane Insoluble Plastic Lead Seal is a scientific laboratory formula made from pulverized metallic lead carried in a special vehicle: smooth, easy-spreading, fast-flowing. It is chemically pure: no red lead, clay filler or dope. An insoluble lubricant as well as a seal . . . Send for prices, sample and literature. Packed in 1, 3 and 5 pounds ready for use.

CRANE PACKING COMPANY, 1800 CUYLER AVENUE, CHICAGO

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Crane Packing Co., Ltd., Hamilton, Ontario, Canada

Branches: Montreal, Toronto, Vancouver

SERVICES: Oil, gasoline, kerosene, benzol, propane, butane, bottled gases, steam, water, hydrocarbons, aqueous solutions, ammonia, CO_2, toxic and inflammable gases, lutings in plugs.

EQUIPMENT: Threaded joints, flanges and gaskets, nuts, caps, valves, plug valve stems and seats, safety fuse plugs, screwed fittings, pumps, cylinder heads, boilers, compressors, stills, tanks, towers, gas stoves, etc., etc.

Extensively used by ✪ LEADING AIRPLANE BUILDERS

A SECRET WEAPON ?

No this isn't a secret type of anti-aircraft gun. It is an FM-2 wagon-mounted rock drill designed especially for deep hole drilling. It is unusually flexible, can be moved from hole to hole quickly and can be set up so as to drill holes at any angle.

War could not be waged without rock drills, since they help mine essential ores, build landing fields for planes, construct strategic highways and help build giant hydroelectric projects to supply the power that keeps our war production machines rolling at an ever increasing tempo.

Today rock drills are helping us win the fight for freedom. Tomorrow when peace arrives, they will be just as useful in rebuilding the war-torn nations of the world.

If you have a problem which requires deep hole drilling, the I-R engineering service division nearest you can supply full details. And our engineers can also show you how Jackbits will speed up your job.

Ingersoll-Rand

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COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

For the Hard-to-get-at Places . . .
NORTON
MOUNTED WHEELS AND POINTS
THAT'S one of the chief uses of these Norton spindle-mounted abrasive wheels—to grind in the hard-to-get-at places, especially on the many intricate, light metal parts used for airplanes.
Another important use in the airplane industry is for burring literally thousands of parts for both plane and motor.
And, of course, Norton Mounted Wheels and Points have been a favorite in the tool room for years for finishing dies and molds and for countless other jobs.
Norton Mounted Wheels and Points are available in nearly 200 standard sizes and shapes—in Alundum and Crystolon abrasives, in vitrified, resinoid and rubber bonds. Catalog 43-CA gives full information. Write for a copy.
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NORTON ABRASIVES

ON THE COVER

OUR cover picture (official U.S. Navy photograph) shows a Seabee—a member of the Navy's Construction Battalion—arriving at a Pacific base. The Seabees are bluejackets who build camps and bases at advanced locations for our fighting men. In addition to being a skilled workman, every Seabee is trained in the use of all weapons of modern land warfare, and he can drop a shovel and use a rifle if the need to do so arises.

•

IN THIS ISSUE

ONE of the domestic tragedies of the war—the sinking of the great ship *Normandie*, renamed *Lafayette*, while in dock—is well on the way to a happy ending. After lying on her side in the mud and murky water for eighteen months, the ex-liner was raised last August and can now be refitted for service. As the *Normandie*, the vessel was for a time queen of the seas, having made the 2,936-mile eastward crossing of the Atlantic in 3 days, 22 hours, and 7 minutes. She lost her crown to the *Queen Mary*, which bettered her performance by nineteen minutes. The restoration of the boat to an even keel was the greatest work of its kind ever performed. Our leading article tells how it was done.

•

SOIL-CEMENT paving is earning a definite place in the light-traffic field because it can be laid quickly at comparatively low cost and with inexpensive equipment. The same advantages have given it important uses during the war. Miles D. Catton, who has been identified with the development of this material from the start, has reviewed its history and current application.

•

BLASTING at a tunnel heading is not an instantaneous operation, but rather a sequence of precisely timed, separate detonations, each one of which disrupts a prescribed section of the rock face. For obvious reasons, it is not possible to follow this progressive shattering process with the eye, but M. W. Terrill has done the next best thing for us by preparing a series of sketches that clearly illustrates it, step by step.

•

ALTHOUGH wartime censorship prevented H. D. Bailey from giving specific production figures in his article on the Yellow Pine Mine, he does tell us that this property is supplying about one-half of our tungsten and a large part of our antimony. The performance of the Yellow Pine is little short of amazing when it is considered that tungsten was discovered there only two years ago.

Compressed Air Magazine

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A. M. HOFFMANN, *Assistant Editor*

D. Y. MARSHALL, *Europe*, 243 Upper Thames St., London, E.C.4.

F. A. McLEAN, *Canada*, New Birks Building, Montreal, Quebec.

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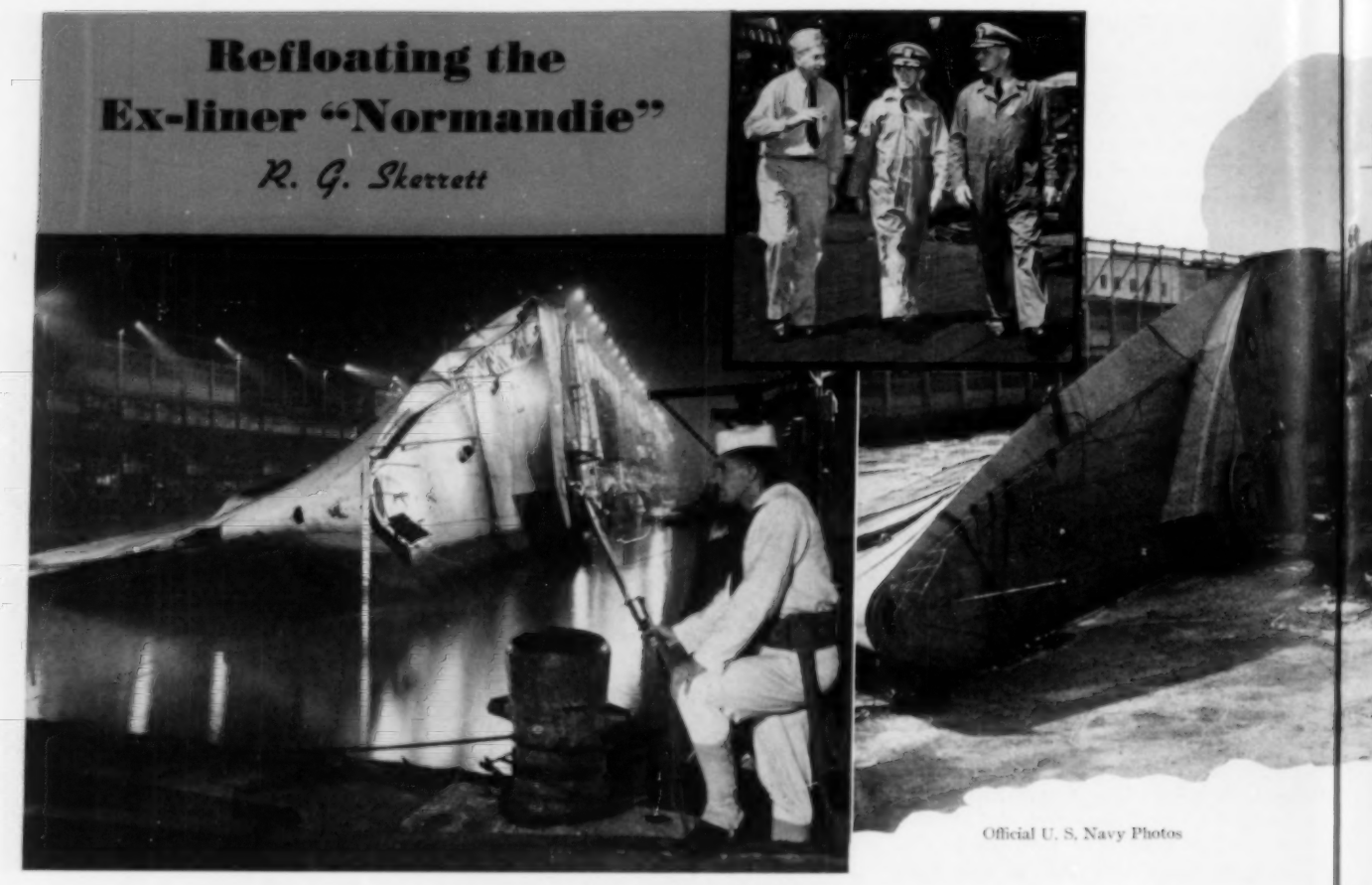
Refloating the Ex-liner "Normandie"

R. G. Skerrett



Official U. S. Navy Photos

VIEWS AS THE WORK PROGRESSED

In the center the huge ship is shown ten days after she keeled over. A section of her forward stack, one of three, had been cut away, although it had not yet been decided whether to scrap or raise the vessel. Above is a night view of salvage operations, which were carried on the clock round under the protection of armed guards. The pictures on the opposite page were taken on August 11 of this year. In the one at the top, water is seen pouring out of the interior through several discharge lines. The lower one shows the shanty from which work was directed. It was built on a hinged platform so that it could be kept level as the ship was righted. The tilt of the catwalk gives a good idea of how much the liner had risen since pumping was started. At the top of this page, Capt. B. E. Manseau, U.S.N., in charge of the salvage operations, is seen conducting Rear Admirals J. J. Broshek (center) and E. L. Cochrane, of the Bureau of Ships of the Navy Department, on an inspection tour.

"LIFTING a lady out of the mud" may be a picturesque way of describing the reclaiming of the ex-luxury liner S.S. *Normandie* from the muck of the water bed in her slip on New York City's North River waterfront. But the righting and the raising of that erstwhile blue-ribbon queen of the transatlantic run has not been an undertaking that can be dealt with in pretty phrases.

The salvage of the U.S.S. *Lafayette*—as the Government has renamed the ship—has been the most stupendous job of its kind ever essayed. The work has been done by the Navy Salvage Service, with the aid of key members of the personnel of the Merritt-Chapman & Scott Corporation. Some readers who follow maritime matters closely may perhaps remember that the latter organization righted and refloated the 11,629-ton S.S. *St. Paul* that sank and capsized at her pier in New York Harbor in 1918.

The *Lafayette* has an over-all length of 1,029 feet, or of nearly $^1/_5$ mile, a beam of 119.5 feet, and is of 79,280 gross tonnage. As will be recalled, on February 9, 1942, while the ship was being refitted as a great troopship, a fire was started in the grand salon on the promenade deck when sparks from an oxy-acetylene torch being used to cut off columns supporting lighting fixtures ignited bales containing life preservers packed with highly combustible kapok. Efforts to halt the spread of the fire were ineffectual. A strong wind spread the conflagration to the two decks above and forward to the bridge before the fire-fighting facilities of New York City, tardily summoned, were in action. Hundreds of thousands of gallons of water were pumped on to and into the burning areas between 2:55 and 6:30 p.m. before the fire was delared "under control." Much of the water passed overboard, but many tons of it remained confined in subdivisions of the upper decks, making the ship so top-heavy that she acquired a heel of 10 degrees to port. It was found impossible to admit water to the lower compartments so as to keep the vessel stable and to make her settle to the bottom upright. Instead, she progressively listed more and more, and finally capsized and sank at 2:45 a.m. on February 10. She settled onto the water bed at an angle of a little less than 80 degrees from the vertical—i.e., her decks instead of being horizontal were nearly straight up and down, with her longitudinal center line at her promenade deck a few feet above the surface of the water, and not quite half of her bottom starboard of her keel exposed to view.

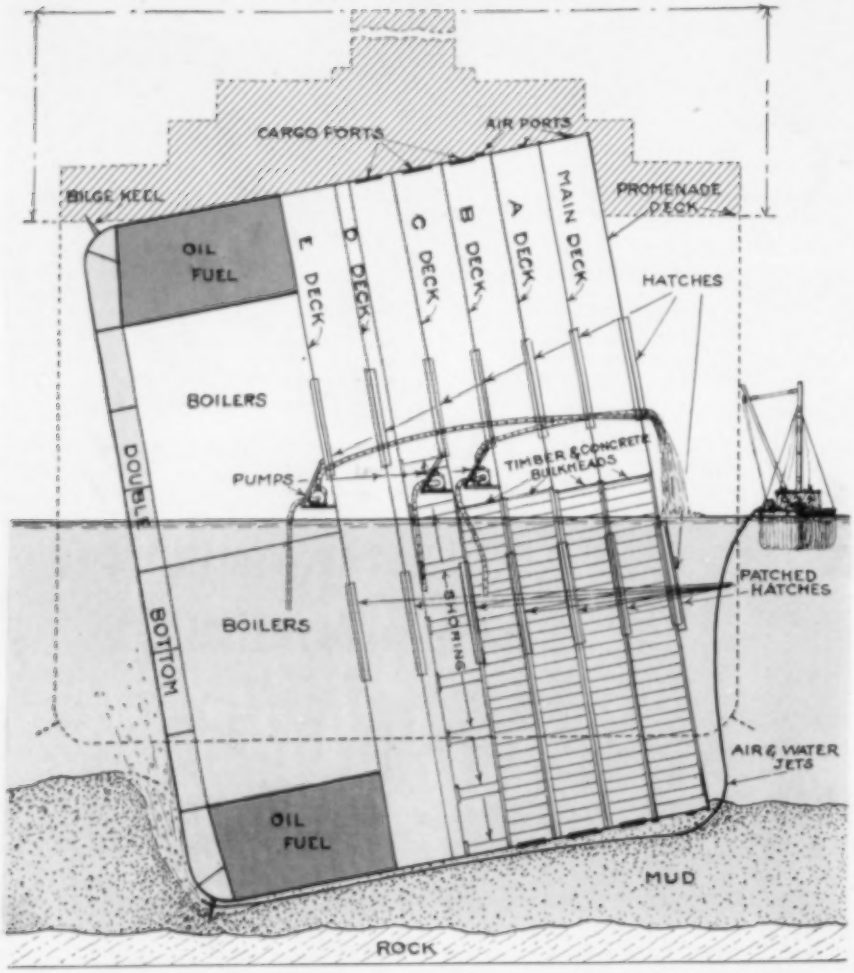
When she sank and turned over, the ship took a diagonal position in the slip between Piers 88 and 90, and her keel, at the stern, crushed some of the piles at the outer end of Pier 88, while her bow projected across and a short distance to the north of the center line of the slip. The bow rose a few feet higher than the stern because the hull rested on the edge of a rock shelf about 250 feet abaft the bow, while the stern was sustained by the mud forming the upper stratum of the water bed in that section of the slip. During the three months following her sinking, the vessel's stern

settled 3 feet more and the bow was lifted about 1 foot. The rock under the forebody acted as a pivotal point, while two-thirds of the length of the craft was sustained by mud of varying density and thickness. The situation was a critical one, whether the Navy Department decided either to scrap or to salvage the wreck. The decision, based upon a report made by a committee of experts both in and out of the Navy, recommended efforts to salvage the craft, but did not designate how the work should be done. That question was put up to the Navy Salvage Service. Commander W. A. Sullivan, U.S.N.,—recently promoted to commodore because of his later accomplishments—was then Supervisor of Salvage, and was recognized as the Navy's leading authority on ship salvage. He was placed immediately in charge of the reclamation program.

Commander Sullivan and his aides, after much study of their problem and with due regard to the structural peculiarities of the ship, concluded that a method of controlled pumping gave greatest promise of success and was likeliest to cost the least and to give the quickest results. These terms are, of course, comparative, because dispatch is measured in months and outlays in millions of dollars.

The *Normandie*, which was launched in 1932 and completed in 1935, was built for the Compagnie Générale Transatlantique (French Line) at St. Nazaire. The ship's unusual hull form was developed by the Russian naval architect Vladimir I. Yourkevitch and modeled to be propelled by four screws driven by four turboelectric units each of 40,000 h.p. and capable of maintaining a speed of 30 knots in all but the roughest of seas and strong winds. In short, to live up to an exacting schedule, winter and summer; and by making numerous four-and-a-half-day runs across the Atlantic to earn returns that would compensate for the $56,000,000 spent on her.

When the vessel turned over and sank she was a craft of eleven decks—her G deck being the lowest and the sun deck the uppermost. The sun deck topped the boat deck, and the boat deck was immediately above the promenade deck. Above the sun deck towered three monster smokestacks and two masts. The first task was to cut away the masts and the smokestacks, and then to remove the hull superstructure down to the promenade deck to lighten the ship and to arrest any further settling of the stern into the mud. Workers equipped with air-driven tools and oxy-



GENERAL RIGHTING SCHEME

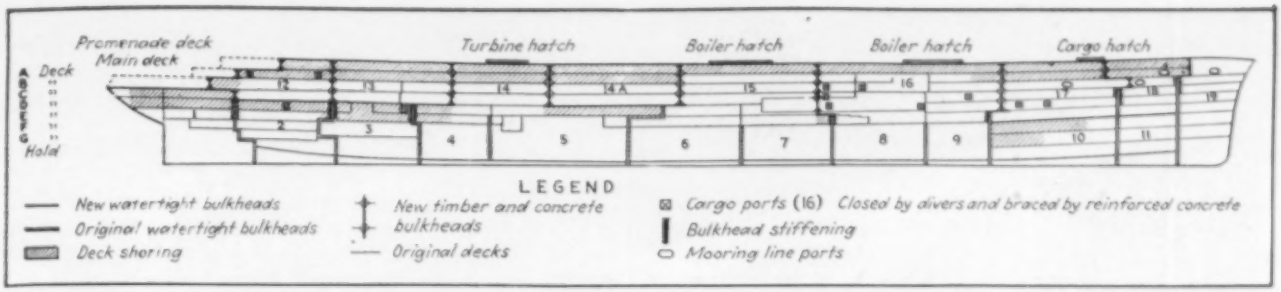
The solid lines indicate how the ship rested in her capsized position and how she was prepared internally for the unwatering operations that permitted her to right herself by her own buoyancy. The dotted lines show her in upright position. The cross-hatched section at the top represents the superstructure that was removed before salvage work was begun.

acetylene torches, with the assistance of wrecking derricks, cleared away the superstructure above the promenade deck and down to the water's edge. Below water, the dismantling work was done by divers using underwater metal-cutting torches, air-driven chipping hammers, impact wrenches, drills, etc. That work was often hazardous, because the divers had to traverse narrow overturned passages and to enter and leave the much cluttered compartments and spaces. The structural labyrinth was made more confusing by the capsized position of the ship, and the divers in making their way in and out had frequently to crawl to reach their goals. They had to be guided alone by a mental picture obtained from a study of a sectional model used to aid them and also by their sense of touch where vision was impossible because of the blackness of the enveloping water.

When the ship was stripped to the promenade deck, then came the far more exacting task of closing all openings below water and doing other work within her body, although flooded at the time, that would create water-tight subdivisions which could be unwatered separately or in unison under the planned arrangement of controlled pumping. In this way the craft would be given gradually sufficient buoyancy to make her roll slowly and easily toward the upright while still resting on the river bottom. When at the desired angle of reduced heel, then still more water would be removed, and the added buoyancy so developed would be enough to make her rise clear of the water bed and float free with still less of a list. To some extent, the *Lafayette's* internal structure could be utilized by the salvors, but a vast deal had to be done inside of her—both above and below water—to make her ready for the great climacteric test. Actual salvage would test the complex and exhaustive computations, many engineering problems that only performance could settle, and, finally, determine the soundness of the work done in constructing the water-tight bulkheads that were to confine the water during pumping and so prevent any surging of the free surfaces of that water.

A force of from 600 to 800 men was steadily employed in doing the work preparatory to beginning controlled pumping; and for considerable periods as many as 75 divers were on the job daily. How well all these men did what was expected of them has been proved by the manner in which the ship rolled upright in her muddy bed—like a slowly awakening sleeper—and then rose free of the resting place she had occupied for eighteen months.

When the ship sank, her body was pressed deeply in the mud, which was thus forced into the ship through every available opening. A great many airports were open or were smashed when the vessel went down, and sixteen large cargo ports were either partly or entirely open. A total of 356 portholes, which had to be sealed underwater, admitted mud into the associated spaces or compartments; and where both doors of a cargo port happened to be open, more than 30 feet of mud squeezed through them and into the interior. Timber staging, hanging over the port side, was smashed as the vessel turned over, and some of the large timbers were driven through the airports. Unattached furniture, stores, and all loose materials and objects inside the craft were thrown to port and landed at the low points in the various subdivisions. The divers entering such sections to take preliminary steps for salvage preparations had to make their way through mud combined with seemingly endless debris of varied sorts. In some instances, the mud overtopped their helmets, and, so hampered, they had to clear away debris before they could close openings in the ship's side and reach positions from which they could guide the intakes of the compressed-air-operated airlifts used to remove 10,000 cubic yards of mud from inside the craft and to discharge it overboard above water. The airlift, without any moving mechanical parts, is admirably suited for such work, and has proved its value over a period of years in reclaiming sunken vessels into which considerable volumes of fluid mud had penetrated. The release of compressed air within a large pipe and near its bottom intake induces an inward flow from the outlying fluid. The compressed air, rising surfaceward within the pipe, creates a column of reduced specific gravity, compared with the outlying mud and water, and the external hydrostatic pressure of the heavier mixture causes it to rush into the bottom of the airlift which offers a ready path up to the surface. The airlifts used on the *Lafayette* were formed of piping either of 4-inch or 6-inch diameter, and compressed air at 75 pounds pressure was



From Engineering News-Record

THE HULL DIVIDED INTO WATERTIGHT COMPARTMENTS

To make the vessel strong enough to withstand hydrostatic pressures greater than those for which she had been built, timber-and-concrete bulkheads and 'tween-deck shoring were erected. These, together with the closing of all openings to the outside, subdivided the hull into watertight compartments, as shown here.

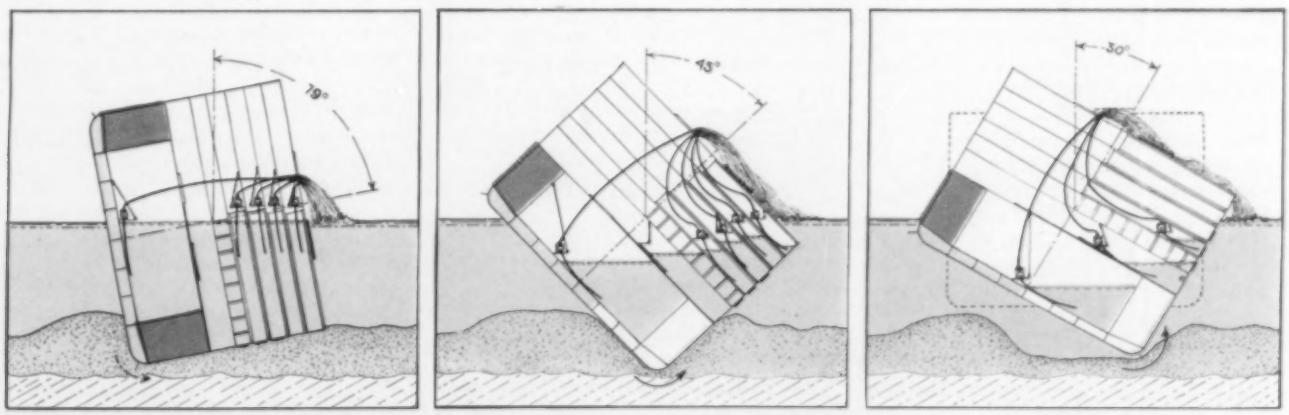
delivered to the bottom of the apparatus by an external ¾-inch hose. Inside the lift the air was released from a distributor in numerous jets. The air, mud, and water so mixed flowed upward with such momentum as to discharge well above the surface of the river.

Compressed air, besides helping efficiently to remove mud from within the ship and serving the divers directly, provided motive energy for pneumatic drills, chipping hammers, air hoists, air-operated sump pumps, and paving breakers. These tools did much indispensable work not only above water but also submerged, relieving the divers of exhausting muscular effort.

The divers spent months not only battling with mud and debris, in utter darkness, but also in fighting the hazard of spun glass that was widely used throughout the vessel for insulation. To quote from an official statement, "It seemed that the fine glass penetrated the skin through the pores and could not be removed except by allowing time to let it grow out. Actually, the divers' lives were continually in danger because of broken glass and the ragged edges of steel, found throughout the craft, which, during the entire operation of the underwater workers, threatened to sever air and life lines."

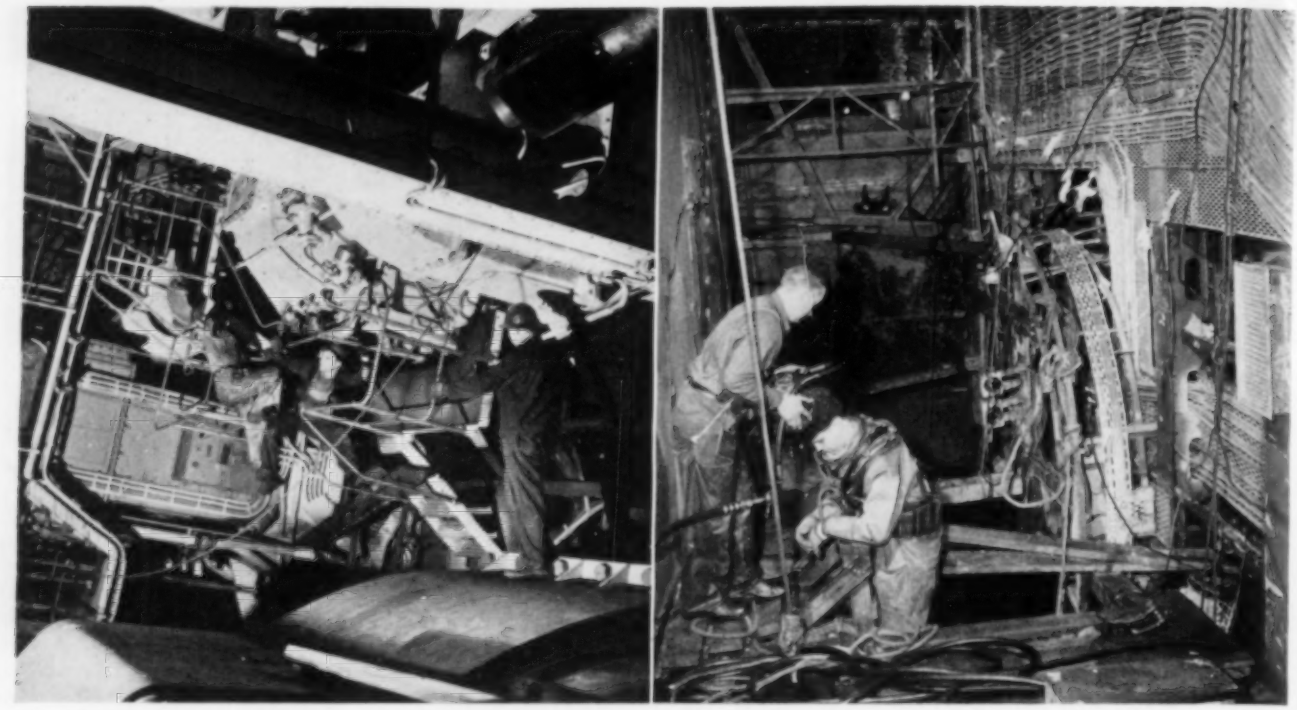
The broken or opened airports were closed primarily with an ingenious device, known as the "Tooker patch," developed by John I. Tooker, the civilian superintendent of the work familiarly known as "Captain," one of Merritt-Chapman & Scott's leading salvage officers of 20 years' experience. The patch consists basically of a circular, thick wooden disk made up of two semicircular sections hinged transversely so it can be folded on itself to pass it out through an airport and then spread so that it will overlap the port. The rim that will be next to the outside surface of the ship carries a flat rubber gasket. Two eyebolts, secured to other eyebolts on the same surface of the patch, can be passed through holes in a strongback that spans the inboard side of a port. These the diver draws tight with a wrench by running two nuts to snug seatings. Elliptical patches and oblong patches, neither of which need be split, can be passed through openings of corresponding shapes and pulled tight against a vessel's plating in much the same manner as just described. Seals for submerged large deck hatches were fashioned of heavy planking and stiffened with structural-steel members. The patch, of course, always amply overlapped the opening to be closed, and gripped the underside of the deck with heavy hook bolts that pulled the patch, with its gasket, into watertight contact with the deck when nuts on the outside were run hard down against washers. Impact wrenches, air-driven, could be used by the divers in dealing with the nuts. Airport and other patches of relatively small size, after being seated, were further reinforced and made more surely watertight by covering them on the inboard side with a patch of concrete placed underwater. The next major task was to subdivide the interior of the vessel into nineteen large watertight compartments and to strengthen existing structures so they would be able to withstand external hydrostatic pressure and dissimilar pressures developed within the ship when the level of the water in adjacent compartments differed because of the controlled pumping.

Keep in mind that the salvors were dealing with a ship lying on her side. They had to have some vertical longitudinal division or bulkhead reaching from bow to stern at approximately



HOW CONTROLLED PUMPING WORKED

The 24,000,000 gallons of water inside the ship was removed by 93 centrifugal pumps having a combined capacity of 160,000 gpm. During the initial pumping stage, the vessel was rotated from 79 to 45° while still resting on the bottom. The pumping schedule was then changed, causing the hull to rise free of the gripping mud while rotating an additional 15°. Fuel oil was allowed to remain in the starboard tanks in order to help counterbalance the weight of the salvage equipment mounted on the opposite side of the ship.



Official U. S. Navy Photos

WORKING WITH THE DECKS ASLANT

When the ship overturned, decks became side walls, as will be apparent when the page is turned to the right and the pictures are viewed from the side. The difficulties that confronted workmen can well be imagined. The illustration at the left was taken in the engine room: the other one shows a diver about to descend between decks.

midwidth so that the weight of water on each side of it could be altered to help in inducing the initial rolling motion and then in controlling the righting action as the craft returned nearer and nearer to an even keel.

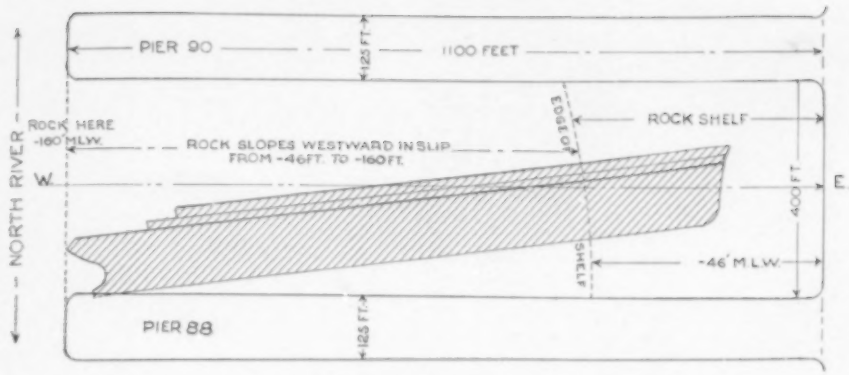
As the accompanying longitudinal section of the vessel shows, C and E decks were made to function as the desired fore-and-aft bulkheads—the decks being shored and existing watertight bulkheads stiffened where deemed necessary. Extending outward from these decks to the promenade deck, thirteen new timber-and-concrete bulkheads were interposed that divided the ship into eight major watertight compartments. These bulkheads differed in length according to their positions and the number of decks they tied together. They were constructed of heavy, grooved timbers tied together with interlocking splines and were erected successively from the top downward. Where the shape of the hull was uneven or curved, the lowermost timber was seated on newly placed bags of concrete that would conform to the vessel's structure and give a snug closure. At the junction with the opposed surfaces of adjacent decks, the bulkheads were fitted into slots formed of reversed steel angles through-bolted to the deck plates, and each end of the bulkhead was sealed on each side to the deck by a triangular column of tremie-poured concrete deposited within a form constructed of timber that also acted as a brace to further tie the bulkhead to the deck plating. On the longitudinal section of the ship, diamond-shaped figures show how the timber-and-concrete bulkheads joined successive decks, and the extent of such bulkheads. The same drawing also indicates how extensively 'tween-deck areas had to be shored to give those decks the strength necessary to withstand the changing hydrostatic pressures. The divers placed 240,500 board feet of lumber in the ship in the form of shoring and bulkheads, and also 1,685 tons of concrete.

The deck openings that were sealed had a combined area of 5,447 square feet, and the total weight of the large patches was 150 tons. The stripping of the superstructure called for the removal of 5,000 tons of material; and it has been estimated that the divers cleared away 8,000 pounds of broken glass. The divers fitted some 4,500 wedges, plugs, and small patches to seal apertures. According to a Navy Salvage Service estimate, the divers used during their work up to June 1 of this year 2,530,000,000 cubic feet of air.

The ship contained 100,000 tons of water and, to provide for removing it, there were placed within her 93 centrifugal pumps—forty 10-inch, twenty-eight 6-inch, and twenty-five 3-inch—having a total capacity of 40,000 tons of water per hour. The pumps were mounted on platforms hinged or pivoted at one end and held horizontal by hoisting gear attached to the other end so they could be held level as the vessel changed her angle of inclination. The pumps were kept as close as practicable to the surface of the water within the craft in order to facilitate their operation. This called for shifting them at intervals as the water level was progressively lowered. All the pumps were driven by gasoline motors. Air-operated sump pumps, which are small and easily moved, were used to drain out-of-the-way structural pockets in which water remained after the principal pumps had disposed of the major volume.

The operation of the pumps inside the ship required the prompt removal of engine discharge gases. The metal-cutting torches also generated considerable volumes of gases, and the decomposition of organic matter in the water—two large sewers discharge into the slip—added further to the safety problem. Testing apparatus for the prompt discovery of noxious gases, and especially deadly hydrogen-sulphide gas, were used continually, and blowers were kept running to insure proper ventilation for the men at work.

The system of controlled pumping was arranged to unwater the ship gradually so that she would respond slowly to the shifting of weight and begin to roll over to starboard. The first stage of this operation was to reduce the heel of nearly 80 degrees to about 45 degrees—the vessel still resting on the bottom and changing her position while rocking on the rounded "turn of the bilge"—the



PLAN SKETCH SHOWING POSITION OF SUNKEN CRAFT

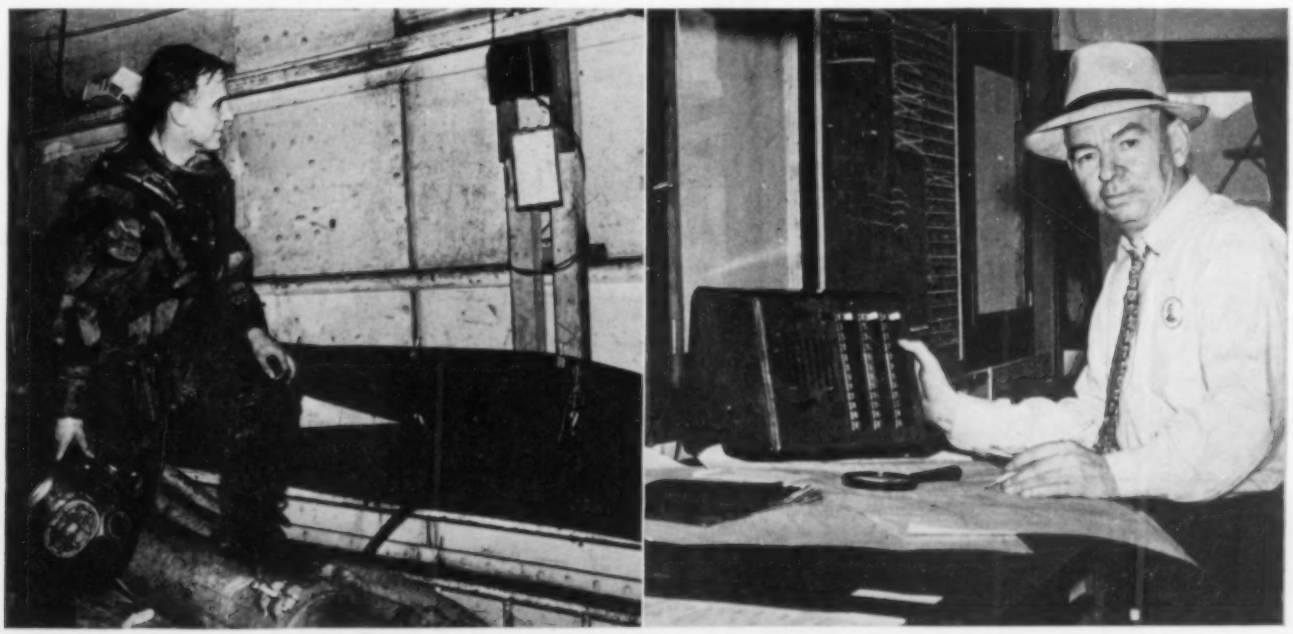
section where the flat bottom merges into the straight upright side of the craft. The intention was to change the pumping schedule then in a way that would give the ship cumulative buoyancy by such degrees that she would acquire flotation and come more nearly upright without any sudden lurching that would cause her to strike Pier 88 where her stern was near it.

The nice control desired during righting and refloating, just described, could be assured only if the ship were released from the grip of the muddy bottom in which she was embedded to a depth of from 10 to 20 feet. To break that hold and to leave the vessel free to rotate, divers led water- and air-jet lines down under the hull. There, in contact with the adhesive mud, and, at the right time, the jets broke the seal. Pumping was under such exacting control that the ex-liner moved counterclockwise by almost unobservable motion that was registered by vertical gauges suspended at different positions. After a week or two of intermittent unwatering the list was reduced to only 30 degrees. Pumping was then halted for clearing away many of the timber-and-concrete temporary bulkheads to reduce the deadweight that would unbalance the craft and hold her with a heel to port. Following that lightening work, it was necessary only to pump out enough additional water to cause the ship to float free from the bottom; and then compensating water ballast, admitted to the starboard or right side of the craft, brought her back to an even keel.

The salvage operations to date have cost in excess of $3,050,000; and it has been estimated that they will finally amount to $3,750,000. The long submergence has undoubtedly greatly damaged at least half of the main turbo-electric propelling units and other parts of the installations similarly exposed to the corrosive or injurious action of water admixed with sewage. However, if the *Lafayette* can be made fit again for a final sum of $20,000,000, that would be far cheaper than constructing anew a troopship of like capacity and correspondingly high speed.

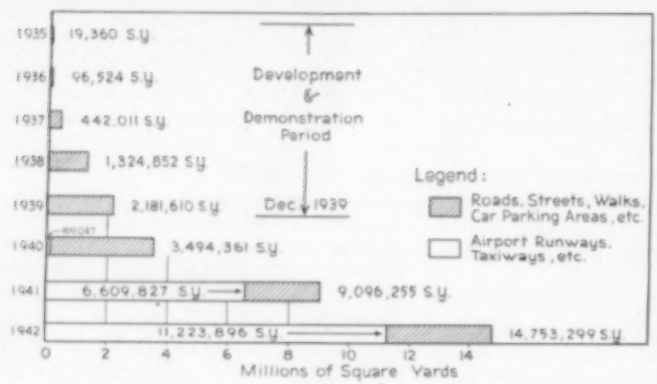
Commodore Sullivan was in charge while the planning of the salvage operations was underway; and he was aided by A.C.W. Siecke, naval architect and consulting engineer of the Merritt-Chapman & Scott Corporation, upon whom rested responsibility for the intricate stability and strength calculations that were required. When Commodore Sullivan was detailed to North Africa to supervise the large and varied ship-salvage operations there, Captain B.E. Manseau, U.S.N., in addition to his duties as Acting Supervisor of Salvage in the Navy Department at Washington, was given charge of the work on the *Lafayette*. The resident salvage officer was Lieutenant Commander C. F. Chandler, U.S.N.R. Second in charge of the salvage operations was M. C. Gilbert, 3d., also of the Merritt-Chapman & Scott Corporation.

Now that the *Lafayette* has been reclaimed from the river bed, the stupendous job of cleaning her out and remodeling her for future service will follow. The public undoubtedly will be deeply interested in what is done to her in the repair yard. In any event, the great engineering job involved in righting her has taken her to the turn in the road that leads to future usefulness.



DIRECTING THE WORK

John I. Tooker, salvage master for Merritt, Chapman & Scott Corporation, kept in touch with operations throughout the 1029-foot ship by means of an Executive communication system. At the right he is seen in his office in a shanty on the main deck with his right hand on the selector panel of the system. By merely pressing a button he was able to carry on a 2-way conversation with anyone of 30 stations in the boat. In the picture at the left, diver Fred Kibble is shown reporting to "Captain" Tooker from somewhere below deck.



Paving with Soil and Cement

*Miles D. Catton**

WE ARE all familiar with the old saying, "Oil and water don't mix," but scientists have learned how to mix oil and water into a multitude of products called emulsions. Civil engineers working with portland-cement concrete discovered that dirt in the mixture was sometimes harmful, so they thought that "cement and dirt don't mix." Here again, research has found ways in recent years of successfully combining soil with portland cement. The result has been a low-cost paving called "soil-cement" for light-traffic roads, streets, and airports.

There are hundreds of thousands of miles of dirt country roads that are not traveled enough to justify paving them with portland-cement concrete used on the main heavy-duty arteries that form the backbone of our Federal and state highway systems. Nor is there money available to pay for such high-type paving on these great mileages of back roads. Yet the latter, clogged with mud in the spring and fall and covered with dust in the summer, are essential to the farmer hauling his corn, his hogs, his hay, his tobacco, his cotton, and his logs to market. The highway engineer was continually searching for something that would enable him to change these mud roads to all-weather roads at a low cost and thus give to every farmhouse the full benefit of the automobile and the truck. The research that uncovered the basic, scientific principle upon which the mixing of soil and cement is based was undertaken by the Portland Cement Association and started in 1935.

The Portland Cement Association is a national organization the purpose of which is to improve and to extend the use of cement and concrete through scientific investigation and field work. Its national headquarters is made up of several bureaus and departments, and it has district offices in the principal cities of the United States from which field engineers operate to help all users of cement and concrete. The search for a low-cost, light-traffic road was part of the work of the association's development department whose director and consulting engineer at that time was the present president, Frank T. Sheets. The latter assigned the job to the writer, who has since then been in charge of soil-cement laboratory research and testing, development, and improvement.

In pioneering work of this nature it is necessary to have an inquiring mind, to think only in terms of essentials, and to be governed by cold facts and results and not imagined consequences. One need only recall "Fulton's Folly" and the Wright Brothers to understand why the answer to the statement, "It can't be done," can be based only on intelligent, actual trial. In planning a low-cost, all-weather road, it was easy to see that the greatest saving in construction cost would be effected by using the dirt of the road itself rather than hauling in sand or crushed stone or gravel. With this

*Manager, Soil-Cement Bureau, Portland Cement Association.

AT HOME AND ABROAD

The accommodating Japanese had already constructed soil-cement runways at Henderson Field, Guadalcanal, when it was captured, and our Marines found a Jap cement cache there and used it to complete the job. At the top-center is a line-up of Grumman Wildcat fighter planes on that field. Pictured just below it is an extensive soil-cement airfield apron at a southeastern Army training school. The view above shows soil-cement construction underway at Pan American Airways' Santos Dumont Field in Rio de Janeiro, Brazil. The huge Army camp illustrated at the extreme left has more than 30 miles of soil-cement streets. The accompanying table records the growth in soil-cement paving in the United States since 1935. At the end of 1942 there was in use in this country 31,408,272 square yards of soil-cement, or the equivalent of 2677 miles of 20-foot roadway.

thought in mind, the project was started by a thorough and systematic study of engineering literature to learn what had been done with dirt in this field.

Literature showed that the idea of mixing soil and portland cement to produce a paving material was far from new. In 1917 Dr. Joseph Hay Amies of Philadelphia, Pa., obtained a patent on a material that he called "soilamies," which was a mixture of roadway soil and cement. About 1920 a patent was issued on "soil-crete" that involved the use of a "magic crystal" of which a small amount was added to each bag of cement to make a paving surface of soil and cement.

In the following years, as state highway departments were organized and developed under the stimulus of Federal Aid, several of them undertook field trials with mixtures of soil and cement. Perhaps the first of these country roads was the section built by the Iowa State Highway Commission about 1922 and described to the writer by Bert Myers, testing engineer. This served quite well until the fall rains softened up the bottom and the top broke through. The South Dakota State Highway Department mixed a stretch of dirt road with cement about the same time.

Succeeding years saw similar efforts by other state highway departments, among them being those of Ohio, California, and Texas. In 1933 and 1934 the South Carolina State Highway Department built several short sections of soil-cement mixtures. However, all these trials proceeded along different lines. Consequently the results obtained varied in an unpredictable and uncertain manner and the reasons and causes for them were unknown. Hence, when the Portland Cement Association began its research it was unable to find any case where a scientific or dependable method had been developed or followed in mixing soil and cement to produce a low-cost paving.

Continuing research led to an intensified study of highway soils and soil testing, which had undergone marked strides under the direction of Thomas H. MacDonald, commissioner of the Public Roads Administration, and his assistants—E. F. Kelley, chief, and C. A. Hogentogler, Sr., of the Division of Tests. In this study was reviewed the work of R. R. Proctor, of the Los Angeles, Calif., water board, who had developed a practical field test for determining the percentage of moisture soil should contain to pack it best. This test was based on fundamental research completed in 1929 by the California State Highway Commission under the direction of T. E. Stanton, materials and research engineer. It showed that for every soil there is a moisture content that will assure the greatest density and stability when the material is packed in the field with road-building equipment.

The basic relationship of moisture content and density and stability of soils offered the first clue to the possible solution of the problem of satisfactorily mixing soil and cement. Further, most soils packed under moisture and density control were sufficiently stable to carry automobiles and trucks without rutting or easy dusting. It was therefore reasoned that if control of the moisture and density during packing gave soils the highest stability, perhaps the same would be true when cement was added.

With this idea in mind, soils of all types, from sands to clays, were obtained from various parts of the United States for test purposes, and laboratory work began in earnest. It was found that the same moisture-density principles held for both soil-cement mixtures and soil alone. It was also discovered that the cement hardened the mixture, made it more durable and strong, and offset to an unusual degree the tendency of water to produce mud.

Questions as to how much cement to use and how to measure its influence had to be answered. The first test specimens contained only a small amount of cement—some one part to nine parts of soil, others as low as one part to 49 parts of soil. With most of the mixture being soil, studying the changes in the character of the material seemed to offer the best method of determining the effect of the cement.

Other laboratory procedures involved wetting and drying and freezing and thawing the specimens repeatedly. In this way it was shown whether the spring and fall rains would turn the mixture into mud, whether dusting would occur in the dry summer months, or whether freezing would tear the mixture apart. However, from a scientific standpoint, it was of more importance that these tests produced shrinkage and expansion

STEPS IN LAYING SOIL-CEMENT

The soil is first pulverized by harrowing (1), after which sacks of cement are spotted at regular intervals (2). Rotary speed mixers, heavy-duty field cultivators, and gang plows serve to mix the soil and cement thoroughly (3), and then water is added (4). The dampened mixture is compacted from the bottom upward by means of sheep's-foot rollers (5), after which the surface is rough-smoothed with motor graders and nail-and-broom drags (6). Steel rollers compress the top surface (7), and the final smoothing and "ironing" is done with multiple pneumatic-wheel rollers (8).

forces many times greater than those that could be obtained readily by breaking specimens in a compression machine or by pulling them apart in a tensile machine.

The test methods were developed and refined with experience and results. Definite patterns emerged, and these showed that many soils became tough, hard, and resistant when about one part of cement was added to nine parts of soil and the mixture, with the proper moisture content, was densely packed. Cement requirements varied with the soil used and were successfully determined in the laboratory by testing each mixture. It was also evident that the cement acted chemically very much like it does in concrete where it causes the mixture to become stronger and harder as it ages. It was learned that the compacted soil-cement would not become mud again when wet, nor tear apart after freezing. Further, that the packed mixture had structural compressive and tensile strength, was characterized by low changes in volume and moisture as compared with soil alone—in short, possessed building-material properties far superior in many ways to those of soil.

The laboratory work was so promising that a field trial was needed to answer such questions as, could soil be pulverized (the farmer told us that it could be); could the road be mixed and packed properly; and would the cost be low? Through the help of the late Dr. Charles H. Moorefield, state highway engineer, and his successor, J. S. Williamson, the South Carolina State Highway Department, the U. S. Public Roads Administration, and the Portland Cement Association entered into an agreement to construct a section of experimental soil-cement road, 1.5 miles in length, near Johnsonville, S. C., applying the scientific principles and control methods developed in the Portland Cement Association soil-cement laboratory. The job was started late in the summer of 1935 with the assistance of W. H. Mills, Jr., testing engineer; A. P. Bolton, assistant testing engineer; and H. L. Sligh, division engineer of the South Carolina State Highway Department. It was completed after nine weeks of hard work. The results seemed very promising at the time, and that they were successful has been verified by the fact that the road has been in continual service for more than eight years.

With the encouragement received from the Johnsonville field experiment, laboratory research and experiments were continued throughout the first winter the road was in use. The following spring, when its condition was found to be quite satisfactory, additional investigations were outlined with an increased laboratory staff under E. J. Felt, a soils specialist who had been borrowed for the initial research from the Minnesota Highway Department. Also, field-demonstration stretches of soil-cement road were constructed by highway organizations in Illinois, Michigan, Missouri, and Wisconsin to determine the practicability of the new type of road in various parts of the country. South Carolina undertook a second scientific job something more than 2 miles long. All these projects turned out successfully, and gave further proof that a low-

FIRST SOIL-CEMENT ROAD

This stretch of highway in South Carolina remains in excellent condition after eight years of service.

cost road could be built of soil and cement.

With the establishment of test methods and construction-control factors that could be depended upon to predict successful results, attention was directed to the very important item of equipment required for this work. It would need to be simple, inexpensive, and readily available to keep costs down to a minimum and thus make it possible for small townships, as well as state highway departments with their larger budgets, to build roads of this kind.

Scientific control involved in soil-cement construction necessitated pulverizing and mulching the soil somewhat the same as a farmer prepares a seed bed. The soil was the engineer's principal aggregate or building material, and it had to be made ready for use by breaking it down so that each grain would be separate from the others. After pulverizing, the cement was mixed uniformly with the soil, and then the moisture was added and also mixed thoroughly. The final and major step was that of packing the material to the tightness or density previously determined by laboratory tests, just as the quantities of soil, cement, and moisture entering the mix had been established.

Many of the operations in roadwork of this kind were similar to those performed by the farmer in cultivating his land. Hence, his regular tools such as disk harrows, spring-tooth field cultivators, gang plows, harrows, and rakes were used and subsequently modified for soil-cement construction. Manufacturers of highway equipment interested themselves in the process and soon began to make special heavy-duty disk harrows, field cultivators, rotary speed mixers, etc., for what the highway engineer called "mixed-in-place construction."

Packing was a vital operation requiring control and uniform density from top to bottom of the roadway. The builder of earth dams was beginning to bring back into service what was termed a "sheep's-foot roller," first used about 1910, that had long spuds or lugs attached to a smooth roller. These spuds reached down into the loose material and packed it from the bottom up, as was required in soil-cement work. It is said that the idea of the "sheep's-foot roller" was conceived while watching sheep mill around in mud in a corral. It was observed that their feet first sank into the mud, but that before long they had packed it into a hard mass with a firm surface.

Following packing, the road was finished by rolling and ironing with the usual smooth-steel rollers and a series of pneumatic tires mounted together closely on an axle to form pneumatic-tire rollers. Experience taught that it was necessary to scratch and blade the surface to give it the required smoothness and to permit the top to knit tightly.

Each succeeding year saw additional demonstration roads built to prove that they were applicable anywhere in the United States with her many soils and climatic conditions. By 1939 these jobs had proved clearly that there was available a practical, low-cost construction method for light-traffic roads. The major problems of testing and building had reached the point where this type of paving was no longer in the experimental or development stage. Accordingly, the Portland Cement Association prepared leaflets and booklets containing all the scientific laboratory test data, proved construction procedures, and other similar information for the general use of paving engineers in the United States. The next year the association received the 1939 American Trade Association Executives' Award for the "outstanding achievement of a trade association in relation to distinguished service rendered by it to the industry it represents, to industrial development at large, and to the public." In 1940, a Soil-Cement Bureau was established to handle this new construction material for the association.

By 1940 the second World War had started and Canada began her pilot-training program which became the model for the Allies. She needed many new airfields, had only limited funds, and was interested in all types of low-cost paving. As a result of the successful use of soil-cement in road work, Canada selected that material for paving the runways, taxiways, and aprons at Borden Field. This was the first application of soil-cement to airports. Soon after the beginning of that project, the first installation of the kind in the United States was made at Westover Field, Chicopee Falls, Mass.

As the construction season started in 1941, the United States was launched on an airfield-building program that our

ENGINEERING USES

The Tennessee Valley Authority is experimenting with soil-cement at Lake Chickamauga, Tenn., as a means of protecting the slopes against erosion above the water line (left). The flume shown at the right was installed by Oklahoma A. & M. College and was lined with soil-cement to study its resistance to scouring.

subsequent entry into the war has expanded to huge proportions. Many of the airports were constructed of concrete because this heavy-duty paving was needed to carry the huge bomber planes that have grown larger and larger as the war has progressed. However, many fields for trainer planes, attack planes, and light bombers could be paved with the cheaper soil-cement.

The airport engineer has learned from experience that soil-cement meets many of his wartime problems of low cost, speed of operations, minimum manpower, machinery requirements, and conservation in the matter of railroad equipment, trucks, and tires. Airport construction projects were often 10 to 100 times larger than ordinary road jobs. They were of such proportions as to permit engineers and contractors to fully organize all operations for greatest efficiency. Manufacturers continued to develop mixing equipment, and special cement spreaders were built. Soon production records not only met but exceeded wartime schedules. It was not long before the usual index of top speed of half a mile of road a day or its equivalent had to be revised upward.

Records of a mile a day were made only to be followed by others of 1½ miles and then 2 miles. Finally, during 1942, several groups built soil-cement runways at a speed equivalent to about 3 miles of road per day. These showings are unsurpassed by any other type of paving, and set new benchmarks. They seem almost fantastic when compared with the paving records of even three years before, and make the weeks spent in 1935 on the first "seedling mile" at Johnsonville, S. C., seem unbelievably slow. Yet the Johnsonville job was remarkable regardless of time or effort because it proved that soil and cement could be used together to form a low-cost construction material.

While the paving engineer was developing and perfecting soil-cement for light-traffic roads, streets, and airports, other engineers began to see that this structural material might serve other purposes. It was not long before it was being used to pave military drill areas and other large expanses so as to make them dustless and mudless. An interesting application was made by Mexican engineers confronted with a problem of water seepage in the bottom of a large earth dam. They were able to cut off and stop the leakage by packing soil-cement on the foundation before rearing the remainder of the structure. Other trial uses included the paving of embankment slopes to prevent washouts. A significant job of this kind was done by the U. S. Corps of Engineers and involved a section of the levees along Lake Okeechobee in Florida.

Shortly after Pearl Harbor, it was necessary to build plane-protection revetments at certain of the west-coast airports, and some of these high walls were constructed in record time with soil-cement. The housing engineer is showing an interest in it as a low-cost building material in the West where the usual materials of this kind are not readily available and where costs must be kept as low as possible.

As scientific control methods predicting and assuring satisfactory soil-cement construction became generally available, engineers in other parts of the world learned how to use soil-cement. Their work has been recorded in engineering literature, which shows that that material has been and is in service in Africa, Argentina, Australia, Brazil, China, England, France, Germany, Japan, Holland, Mexico, and New Zealand. In general, they have employed it for paving roads and airport runways.

The use of soil-cement in wartime was foreshadowed in 1938 in China at the beginning of the Sino-Japanese war. At that time Fu-Hua Chen, designing engineer, National Economic Council, Republic of China, built a section of soil-cement road with coolies between Sian and Lanchow on the famous old Russian caravan route. Somewhat later, when it became necessary to open up the Burma Road, soil-cement was likewise resorted to during its developmental stages.

The demand for soil-cement in military operations has increased with the war activities. U. S. Army Engineers and the U. S. Air Corps interested themselves in this type of construction even before war was declared, as did others who foresaw the need of emergency airfields. As a result, military engineering units that may be called upon to build airports are being trained in soil-cement construction and equipped with the necessary machinery. Among those receiving such instruction are U. S. Army Engineer Aviation Units, Airborne Engineer Aviation Units, Navy "Seabees," and Marine Engineer Aviation Units.

In recent weeks the War Department has released official information telling us that the Japs were building some of the runways at Henderson Field, Guadalcanal, of soil-cement when it was occupied by our forces. At the same time the Marines also captured a large cache of cement that the Marine Engineer Aviation Units used in soil-cement construction to improve facilities at that airport. U. S. Army Engineers and Australians are utilizing it for some of their emergency runways in Australia; and the British have learned that the Germans have been constructing roads of soil-cement and also paving streets in some of their housing developments with the material. It is fully expected that, as the facts become known, it will be found that soil-cement has been used effectively in many other instances in the field of military operations.

DEVILDOG ROADBUILDERS

At their training base somewhere in North Carolina, aviation engineer units of the United States Marines receive instruction in the construction of soil-cement highways and airfield runways.

Yellow Pine Mine —Strategic Metal Bonanza

*H. D. Bailey**

MODERN FACILITIES

Hemmed in by 8000-foot peaks, the Yellow Pine Mine is ordinarily inaccessible by highway for more than seven months of the year, and for the past ten years the airplane has been the principal means of winter transportation. At the top, a Travelair plane is shown landing at the airport. At the nearby village of Stibnite an extensive construction program has provided comfortable living quarters for married employees. Several of the modern homes are pictured above.

CHINA, before the Japanese invasion of Burma, was our principal source of both tungsten and antimony. Imports to the United States since early 1942 have been small. Fortunately for the war effort, increased domestic and South American production has more than compensated for this loss. The Yellow Pine Mine is the largest cause for this increase, and it is currently furnishing about half of the United States tungsten requirements and a large percentage of the antimony we need.

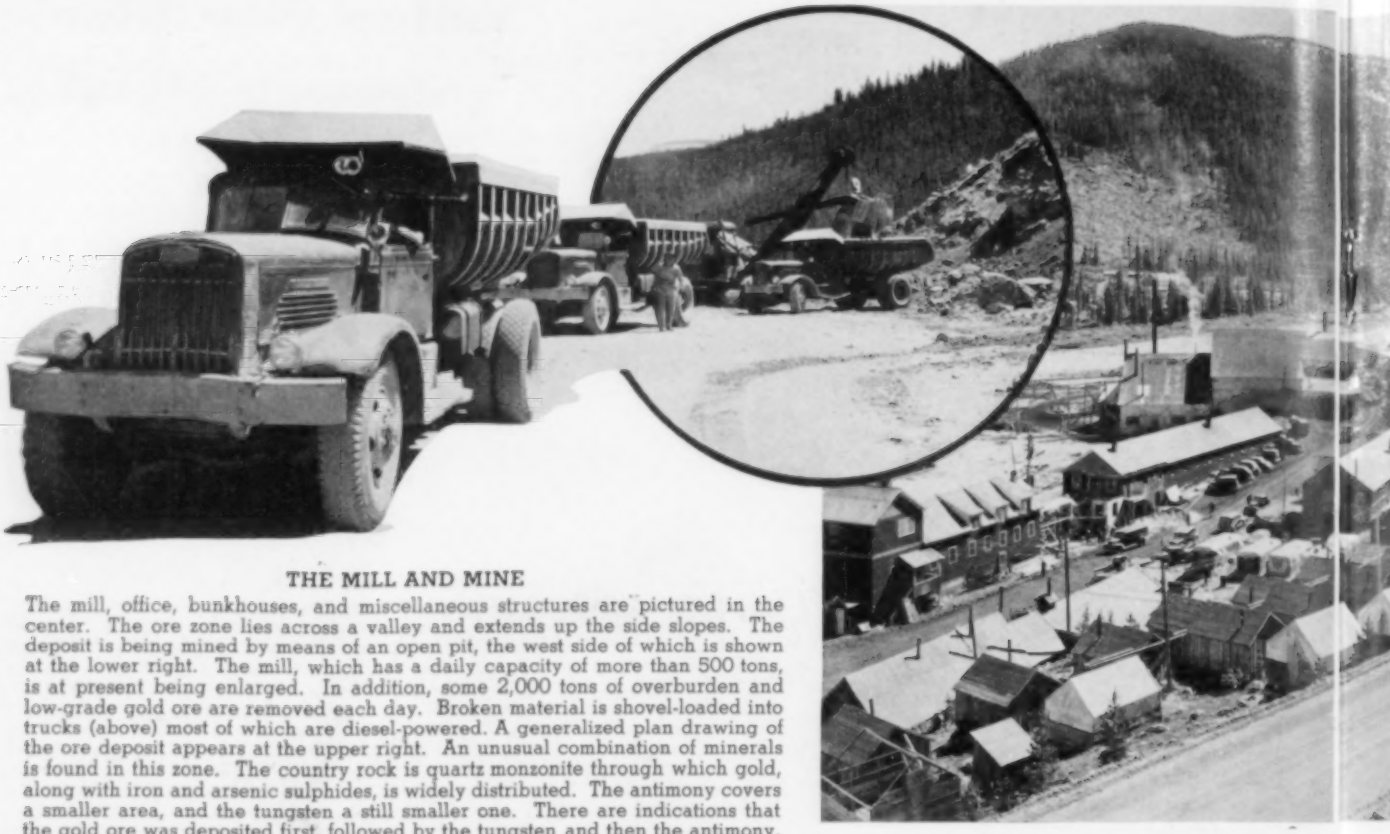
Behind this timely development is a story of the discovery of an ore body rivaling the old bonanza gold mines in concentrated value. It is a story of mining luck that could not have happened had it not been for the courage and faith of a few men who continued to develop and hold the property through many unprofitable years. The immediate and full realization of these two strategic metals is attributable to the unselfish efforts of the Bradley Mining Company, owners and operators of the Yellow Pine Mine.

The discovery of tungsten at the Yellow Pine in February, 1941, was widely publicized as one of the most dramatic and important ore finds in recent years. Donald E. White of the U. S. Geological Survey detected the tungsten mineral scheelite while examining thin sections of diamond-drill cores under a microscope. The drilling was started in 1939 by the U. S. Bureau of Mines to open up reserves of antimony ore. Even without the tungsten this project was a success, and a great deal of credit for it is due to the two aforementioned government agencies and their personnel. Most of the Yellow Pine deposit is low-grade gold-antimony ore, and while open-pit mining was started in 1938, the margin of profit was too small to justify the extensive drilling program that was carried out.

The Yellow Pine Mine and the nearby village of Stibnite are located 160 miles by highway and mountain road northeast of Boise. They are near the geographical center of Idaho and on the edge of one of our last primitive areas. Within a radius of 100 miles or more, heavily timbered mountains rise uniformly to an average elevation of 8000 feet. Innumerable streams and tributaries of the Salmon River seem to flow in all directions, but the dominant drainage is to the north. This fact has been the basic reason for the slow development of the region, for access has to be from the west and roads must cross high divides. Winter snows are heavy and roads are normally impassable for seven months. For the past two years they have been kept open throughout most of the cold season, but at heavy expense. Winter travel by airplane has been the rule for more than ten years.

In 1927 the late F. W. Bradley became interested in the Meadow Creek gold mine and in several adjoining prospects. At a cost exceeding $1,000,000 a 14-mile road was built to the property; a mill, power plant, and camp buildings were constructed; and the mine developed. Mr. Bradley was granted an option on this and other properties from the United Mercury Mines Company; and since 1916 J. J. Oberbillig, president and manager of the company, has retained

*Resident Manager at Stibnite, Idaho, for Bradley Mining Company.



THE MILL AND MINE

The mill, office, bunkhouses, and miscellaneous structures are pictured in the center. The ore zone lies across a valley and extends up the side slopes. The deposit is being mined by means of an open pit, the west side of which is shown at the lower right. The mill, which has a daily capacity of more than 500 tons, is at present being enlarged. In addition, some 2,000 tons of overburden and low-grade gold ore are removed each day. Broken material is shovel-loaded into trucks (above) most of which are diesel-powered. A generalized plan drawing of the ore deposit appears at the upper right. An unusual combination of minerals is found in this zone. The country rock is quartz monzonite through which gold, along with iron and arsenic sulphides, is widely distributed. The antimony covers a smaller area, and the tungsten a still smaller one. There are indications that the gold ore was deposited first, followed by the tungsten and then the antimony. The map shows the diversion dam and tunnel which serve to keep the water of the East Fork River out of the workings. For ten months of the year, when the stream flow is low, the tunnel can be used for development purposes and has therefore been provided with rails.

his faith in the mineral possibilities of the wilderness area. He is still very active in the exploration and operation of neighboring mines and prospects. After the installation of the 150-ton milling plant in 1932 there ensued a long, lean period in which little was accomplished except the exhaustion of the better-grade ore from the Meadow Creek Mine.

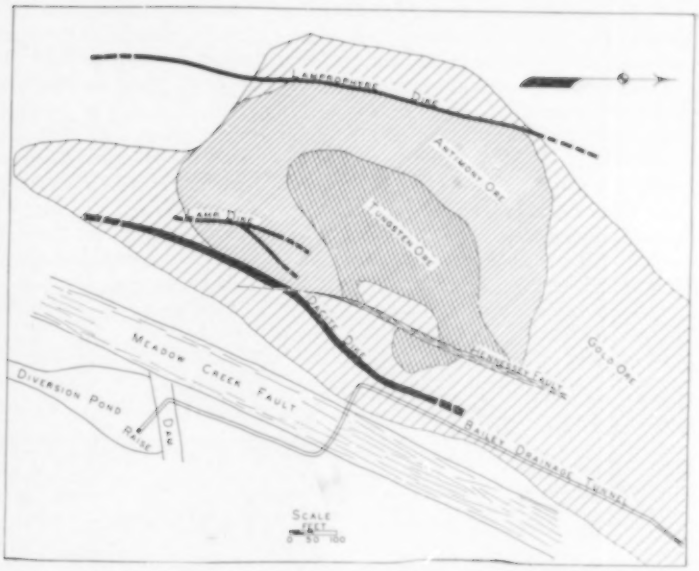
Active open-pit mining was started at the Yellow Pine Mine 2½ miles to the north in 1938. Fortunately, the Hennessey group of claims, on which this deposit is located, was acquired in 1933. The Yellow Pine Company was the operator until August, 1938, when the Bradley Mining Company took over all its property. John D. Bradley, as the vice-president and general manager of the latter, deserves particular credit for directing the revitalization of a decadent mine. It is noteworthy that Yellow Pine was a profitable and expanding enterprise before tungsten was discovered.

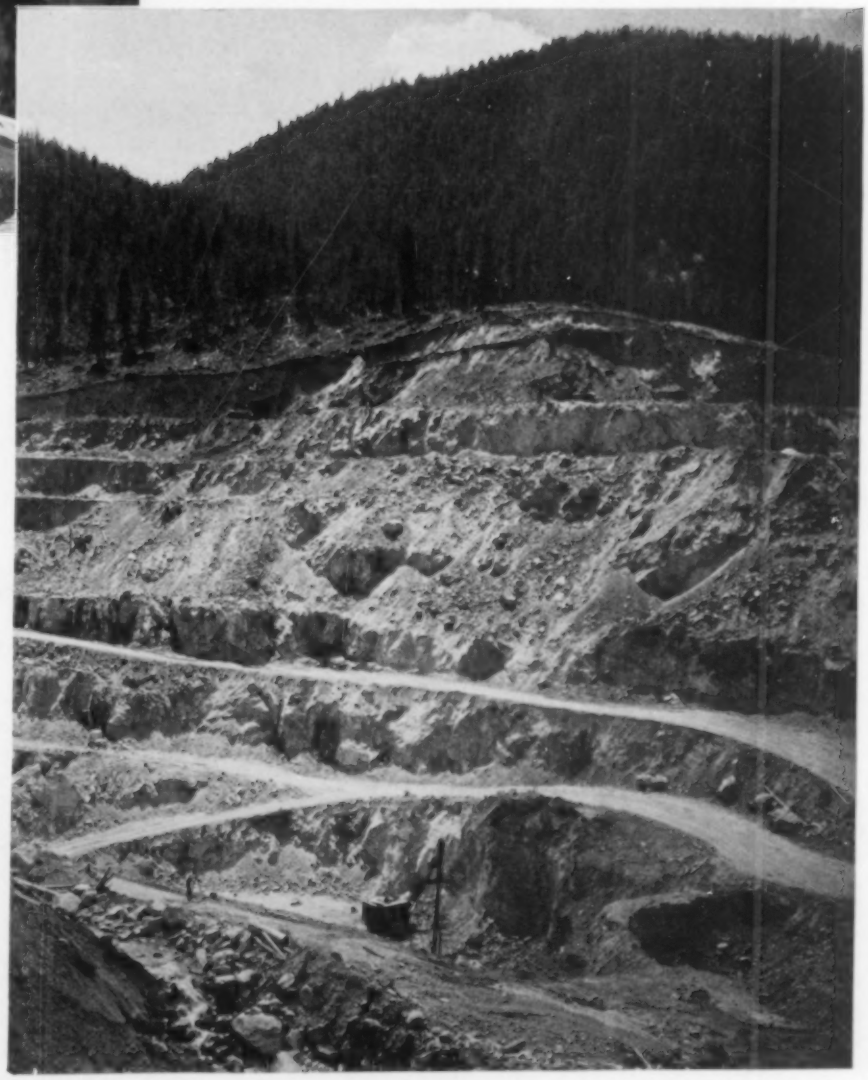
The geology of the Yellow Pine Mine seems relatively simple in outline, but to those that have studied it, many perplexing problems have become evident. Most of them are due to the characteristic uniqueness of the deposit, and theories evolved in other districts don't often apply. In spite of the divergent opinions regarding the type and origin of this occurrence, a structural and mineralogic pattern is being worked out that will be used in expanding the ore reserves and in finding new ore bodies.

The predominant country rock is quartz monzonite of the Idaho batholith. Dikes and irregular bodies of aplite and pegmatite are abundant, particularly in or near ore zones. The most important structural feature is the Meadow Creek fault, which turns to the northeast at a point south of the Yellow Pine and from there extends south for a distance of 2 miles to the Meadow Creek Mine. The latter's ore bodies are small, but similar in most respects to those of the Yellow Pine. Lamprophyre and dacite dikes are present, and nearby, to the east, is found a roof pendant of metamorphosed sediments. Recent glacial, stream, and detrital deposits are extensive, and rock outcrops are few.

The combination of minerals found in this ore is unusual and may be the result of superimposed mineralizations. Pyrite and arsenopyrite with gold are widely disseminated in the quartz monzonite through selective replacement, and much of the original texture and appearance of the quartz monzonite are retained. Aplite bodies were not mineralized readily, and complex fracture systems localized gold values. This low-grade gold ore, which is by far the most extensive of the deposits present, probably represents an early mineralization. The antimony mineral, stibnite, and the tungsten mineral, scheelite, are of later origin than the gold and are often not present with the latter. Scheelite is generally found in the stibnite ore, but the reverse is not true. Stibnite may exist either as disseminated ore in high-grade stringers or as lenses, usually with fine-grained quartz. Scheelite is the most limited in extent of the ore minerals and is confined by cross fractures and, most unexplicably, to certain horizons. The scheelite-stibnite ore in the center of the Yellow Pine deposit constitutes a most remarkable mineral concentration. A typical assay would be 2.5 per cent tungstic oxide, 3.5 per cent antimony, 0.06 ounces of gold, and 1.5 ounces of silver.

The Yellow Pine open pit is beginning to resemble, on a small scale, the Bingham Canyon copper pit. The ore deposit has some of the porphyry copper characteristics, and since it extends diagonally across the canyon the present pit is already of fair size. The main highway to the mine, mill, and residential districts farther up the canyon has been moved several times. The East Fork River, with a flood stage of more than 300 second-feet, presented a problem that has been taken care of with a 3500-foot drainage tunnel. This project, including timbering and flume construction, took about five months to complete. It has a cross section of 7x9 feet, with a permanent track level 30 inches





above the sills. For ten months of the year it can be used for development work.

Overburden in the canyon bottom completely covered the tungsten ore to depths of from 40 to 140 feet. While it was being removed and benches were established, it was necessary to mine underground by square-set methods. All mill ore is now coming from the open pit, and, in addition, 2,000 tons of overburden and gold ore must be removed daily. Over-all pit slopes of 45° were planned, with benches 30 feet wide and 30 feet high. Some are being made higher, and 10 per cent access roads temporarily eliminate others. Drilling equipment includes two Bucyrus-Armstrong 22T churn drills and two Ingersoll-Rand X-71 wagon drills. Six-inch holes are drilled by the former and 2-inch holes by the latter. Ingersoll-Rand Mobil Air compressors with a capacity of 500 cfm. are in operation. A powder foreman spots holes and calculates loads. About 5 tons of rock have been broken per pound of powder, and Dupont dynamites and Primacord are used exclusively.

Diesel-powered shovels are on the job and include a 1½-yard Lima and three Bucyrus-Erie machines—a 2½-, a 2-, and a ¾-yard. Seven tractors with "dozers" are available, and five of them are International TD-18's. All ore and mill concentrates are transported by trucks, of which 26 are driven by HB Cummins diesel motors and are preferred to gasoline trucks. Twelve of the diesels haul the concentrate to the railroad at Cascade, the average load being 12 tons, and bring supplies back. For pit haulage there are 8- to 14-yard rock bodies on single- or dual-drive Autocar and Sterling trucks. Ten to 20 gasoline trucks are being used along with a number of utility and service trucks. Experience has indicated that at least one-quarter of each of the different types of equipment in service can be expected to be idle at one time for repairs.

The present milling plant is handling more than 500 tons per day. The tungsten-antimony ore requires fine grinding properly to liberate the various minerals. Four Hardinge ball mills are in operation, and the addition of an 86 Marcy mill this fall will greatly increase the daily capacity. The crushing, flotation, and filter installations are ample for the larger tonnage.

In outline, the flotation scheme is as follows: Iron sulphides are initially floated in the usual manner, but in an alkaline circuit. Stibnite is activated and floated in a more acid circuit by adding lead acetate. This concentrate contains more than 50 per cent antimony, plus 15 to 20 ounces of silver. After conditioning with alkaline reagents (pH to 11.0) and gangue depressants, a No. 1 scheelite concentrate is floated with oleic acid. This assays between 40 and 55 per cent tungstic oxide and represents 60 to 75 per cent of the tungsten recovered. Tailings are conditioned again and a No. 2 scheelite concentrate is floated with Perkins Oil. This assays about 10 per cent tungstic oxide and is shipped to a chemical plant in Salt Lake City.

The Yellow Pine mill requires an unusual amount of power besides that used in mining, shops, and residential districts. It has been necessary to install twelve diesel-electric generators to supplement three hydroelectric plants, but this is still insufficient and does not allow for expansion. To correct this condition and to eliminate the heavy expense of operating so many units, the Idaho Power Company is running a 110-mile transmission line into the property. This is a very difficult undertaking in such a mountainous country, but it is scheduled for completion before November, 1943.

To promote and to clarify the relationship of employees to management, the company has published and distributed a booklet entitled *Employees Benefit Plans*. It is essentially a contract, and outlines a bonus system based on the monthly production of tungsten. Workers are divided into six classes, and the bonus in cents per hour is added accordingly to the individual's basic rate. The average bonus paid during the time this plan has been in operation has been from 8 to 35 cents per hour, depending on the classification. Twenty-five shifts a month qualifies an employee for the bonus, and sickness or accident is not considered lost time. Provision is made for the hospitalization and medical care of all workers and their families on a monthly charge basis, and a completely equipped modern hospital with a competent doctor and staff is available. Employee contributions collected so far have paid approximately one-third of the operating expenses of that establishment. Besides, group insurance is furnished at low rates.

A workers' grievance committee has been organized, and its bimonthly meetings with the management have been of great value in adjusting minor complaints. Safety, first-aid, and fire-protection measures are functioning successfully. All employees are eligible for vacations with pay, and each 6-month period of continuous employment (150 shifts) earns one week.

The increase in the working force during the past two years has resulted in an acute housing problem, since more than 80 per cent of the men have families. A school and recreation hall have been built, the general store will be enlarged, and various other commercial establishments are being provided. In pretungsten days there were less than twenty families in the camp and these lived in shacks, while most of the employees were quartered in a bunkhouse. Stibnite is now an incorporated village embracing an area of 10 square miles. It will soon be a model community with more than 200 homes and with most of the metropolitan facilities. In addition, the nearby wilderness area affords outdoor recreation such as hiking, fishing, hunting, and winter sports, all of which are being encouraged.

PERSONNEL

The Yellow Pine Mine is one of several properties owned by the Bradley Mining Company, San Francisco, Calif., which is conducted by three sons of the late F. W. Bradley, formerly one of the nation's outstanding mining men. Here is shown the Yellow Pine operating staff grouped in front the office. Rear row, left to right: E. E. Coleman, electrical superintendent; R. J. McRae, mill superintendent; W. H. Nelson, accountant. Center row: J. A. Mecia, chief engineer; V. F. Sharp, chief clerk; James P. Bradley, executive director. Front row, L. H. Bain, truck superintendent; H. D. Bailey, resident manager and author of the accompanying article; John D. Bradley, vice-president and general manager; T. J. Fleming, mine superintendent and assistant resident manager.

TUNNEL LOCATION

From Grand Lake, on the western slope of the Continental Divide, the bore will follow a northeasterly course, with its east portal located a few miles south of Estes Park village. The water it will carry will be used for the supplemental irrigation of land already under cultivation north of Denver. Sugar beets is the principal crop raised. The water will be diverted from the headwaters of the Colorado River.

How a Tunnel Drill Round is Blasted

M. W. Terrill

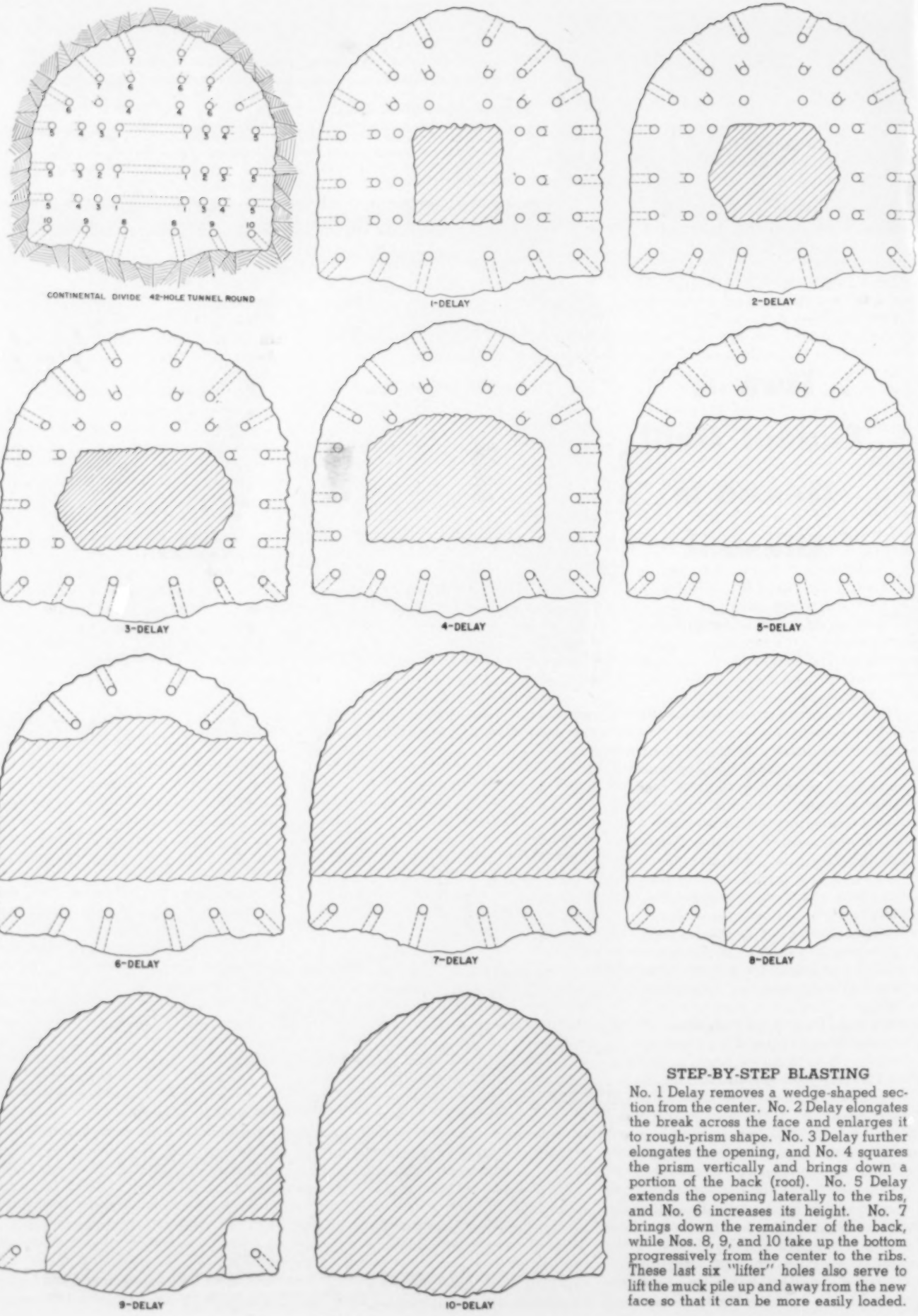
THE accompanying series of drawings shows how a typical blasting round breaks the rock at a tunnel face. It will be noted that ten separate explosions, composed of from two to eight holes each and fired in sequence, make up the blast. This progressive firing is accomplished by using delay electric blasting caps. The general scheme is to remove a small section of the rock face first and then to enlarge this, step by step.

The number of boreholes and the pattern of the drilling and blasting round vary according to the size of the tunnel, type of rock, and the individual preference of the tunnel superintendent. In any case, there is only one free face, the tunnel breast, to which ground can be broken. The first step, then, is to make an initial opening, usually in the center, to form additional free faces to which the remainder of the holes in the round may break. This first opening is called the "cut," and it may vary in form. The "V" or "wedge" cut that is illustrated here is one of the oldest and most widely used types. The cut is the most essential part of the round and must be blasted out completely if the remaining holes are to do their work effectively. A little extra time and care devoted to spotting the cut holes and to drilling them at the correct inclination and to the prescribed depth will, consequently, insure "pulling" the round clean and breaking the rock to the full depth of the boreholes.

These sketches represent the principal drill round used in the 13.06-mile Continental Divide Tunnel, the most important feature of the U.S. Bureau of Reclamation's Colorado-Big Thompson Project in Colorado. The bore will convey water for irrigation and power development from the western side of the divide to the eastern side. It has a nominal diameter of 12½ feet and is being driven from both ends. After work had been conducted for two years, the operations were suspended by Government order on December 31, 1942. At that time, the east heading had been advanced 34,757 feet and the west heading 20,765 feet—a total of more than 55,500 feet and about 80 per cent of the entire length. Last July permission was granted to resume operations in the tunnel, to construct a conduit from its eastern portal to the Big Thompson River, and to build a diversion dam to create Shadow Mountain Lake, which will feed water to Grand Lake and thence into the western end of the tunnel. It is expected that these structures will be completed by the spring of 1945 and that 90,000 acre-feet of water annually will then be available for passing through the divide. Completion of Granby Reservoir, which has been deferred until the war is over, will increase the annual supply of water for diversion to more than 300,000 acre-feet.

As the tunnel progressed, widely varying rock conditions were encountered. At the eastern end they were rather consistently good, but at the western end they ran true to the expectations that had been based on experiences with tunnels previously driven through that general section of the divide. For the first few thousand feet they were generally bad, and this accounted in large part for the slower advance from that end. As driving continued, however, rock conditions improved, and at the time work was suspended the rock was so similar at the two working faces that samples were almost identical.

Drilling methods were naturally varied to cope with the changes in rock as they were encountered. In hard, blocky ground, which tends to break large and to overbreak, a drill round was used that included a relatively large number of shorter-than-average holes. When soft, solid ground was met, still fewer holes were drilled to average depth; and whenever the soft ground exhibited a tendency



STEP-BY-STEP BLASTING

No. 1 Delay removes a wedge-shaped section from the center. No. 2 Delay elongates the break across the face and enlarges it to rough-prism shape. No. 3 Delay further elongates the opening, and No. 4 squares the prism vertically and brings down a portion of the back (roof). No. 5 Delay extends the opening laterally to the ribs, and No. 6 increases its height. No. 7 brings down the remainder of the back, while Nos. 8, 9, and 10 take up the bottom progressively from the center to the ribs. These last six "lifter" holes also serve to lift the muck pile up and away from the new face so that it can be more easily loaded.

TUNNEL PROFILE

to run, the depth of the entire round was decreased. This shortened round was employed in bad ground so that supports could be carried close to the face at all times. For what might be considered average rock conditions, consisting of relatively hard but rather free-breaking granite, the usual round consisted of from 36 to 42 holes, a 7-foot depth being adopted on the east end and a 9-foot depth on the west end. The data used in making up the accompanying progressive blasting sketches were supplied by John R. Austin, general manager for the contractor at the west heading.

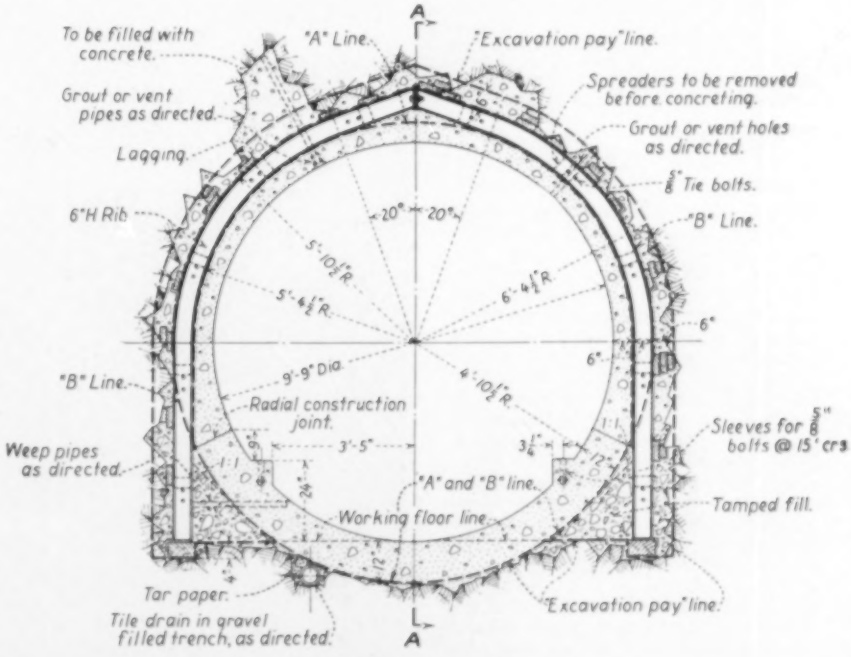
The drawing on this page was reproduced from the official Bureau of Reclamation specifications and shows a typical completed tunnel section with the modified horseshoe-shaped tunnel as excavated and then lined with concrete to form a circular bore. The "A" Line outlines the section within which no portion of steel support shall be permitted to remain, and the "B" Line the section within which no lagging, spiling, crown bars, spreaders, unexcavated material, or tamped fill shall be allowed to remain. The Excavation Pay Line bounds the section to which contractors are paid, regardless of whether their excavation falls inside or outside of the line. Because the tunnel will be lined with concrete under a later contract, a penalty of $15 per cubic yard is charged against the driving contractors for yardage excavated in excess of the calculated amount in this minimum section. They must therefore drill and shoot accurately to line.

Various typical tunnel sections are provided for in the specifications, ranging from steel-liner-plate support through rib supports of both timber and steel H-beam construction down to the unsupported section. Each method of support requires a different size of tunnel section to accommodate it. The typical section shown employs a 6-inch steel H-beam rib support and would be driven 12 feet 9 inches wide. In unsupported ground, the space between the "A" and "B" lines occupied by the 6-inch H-beams would, of course, be omitted; the two lines would coincide; and the heading would be driven one foot narrower. Approximately half the total footage thus far driven has been unsupported, and the other half has been almost entirely supported by 6-inch steel H-beams.

From the foregoing it will be apparent that the contractors are required to excavate to the "B" Line, are paid for all rock removed within the Excavation Pay Line, and are penalized for excavation outside of the latter line. Accordingly, it is to their interest to leave in place as much rock as possible between these two lines. To effect this, they normally collared the rib (outer) holes on the "B" Line and endeavored to bottom them on the Excavation Pay Line.

The first sketch on the preceding page shows a typical V-cut, 42-hole round in average ground and gives approximate locations, spacing, and direction of the holes, and also the order of firing them. Such a round is worked out so that the specified section of rock will be pulled with as few holes as practicable, careful consideration being given to preventing overbreak and to sizing the muck so that it can be readily handled. Controlled breakage of the rock to tunnel line as well as to unit size requires that the holes be accurately placed, as each must have its correct burden if it is to break the ground allotted to it. Also, the several series of holes must be fired in correct sequence so that each one will relieve the one following. The "V" cut in the center of the face is drilled with steels 2 feet longer than standard, and the holes are directed so that they will intersect at their bottoms. These holes are fired first with No. 1 Delay, and succeeding delays fire automatically at intervals of from 1 to 2 seconds. The central cut is, roughly, shaped like a piece of cake. All other delays break to this section.

The Continental Divide Tunnel is being driven by two contracting firms: Stiers Brothers Construction Company at the west end, and S. S. Magoffin Company, Inc., on the east end.

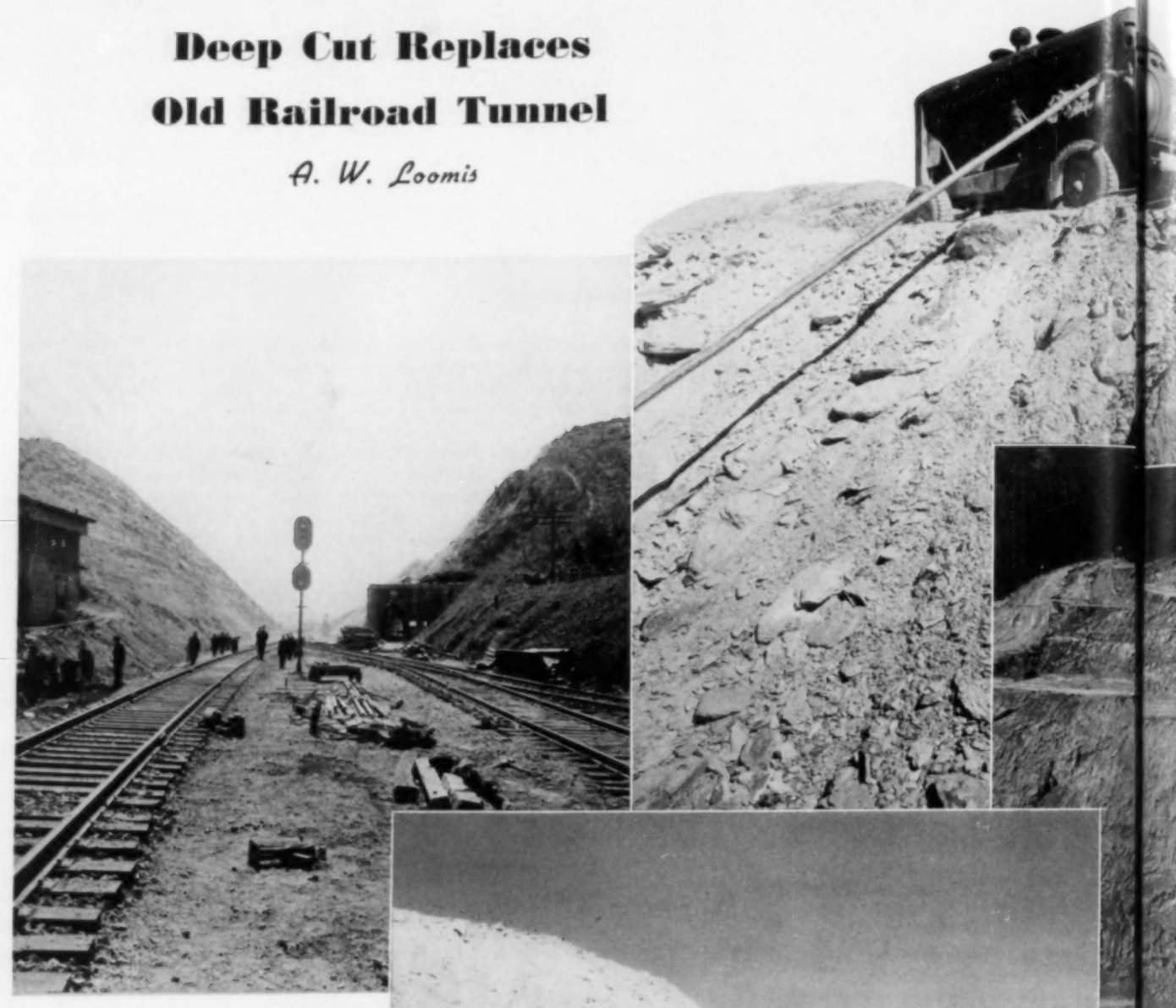


TYPICAL SECTION

Here are shown the horseshoe-shaped excavation, 6-inch H-steel rib support, and concrete lining forming finished circular bore. In self-supporting ground the steel support is omitted and the tunnel is driven one foot narrower.

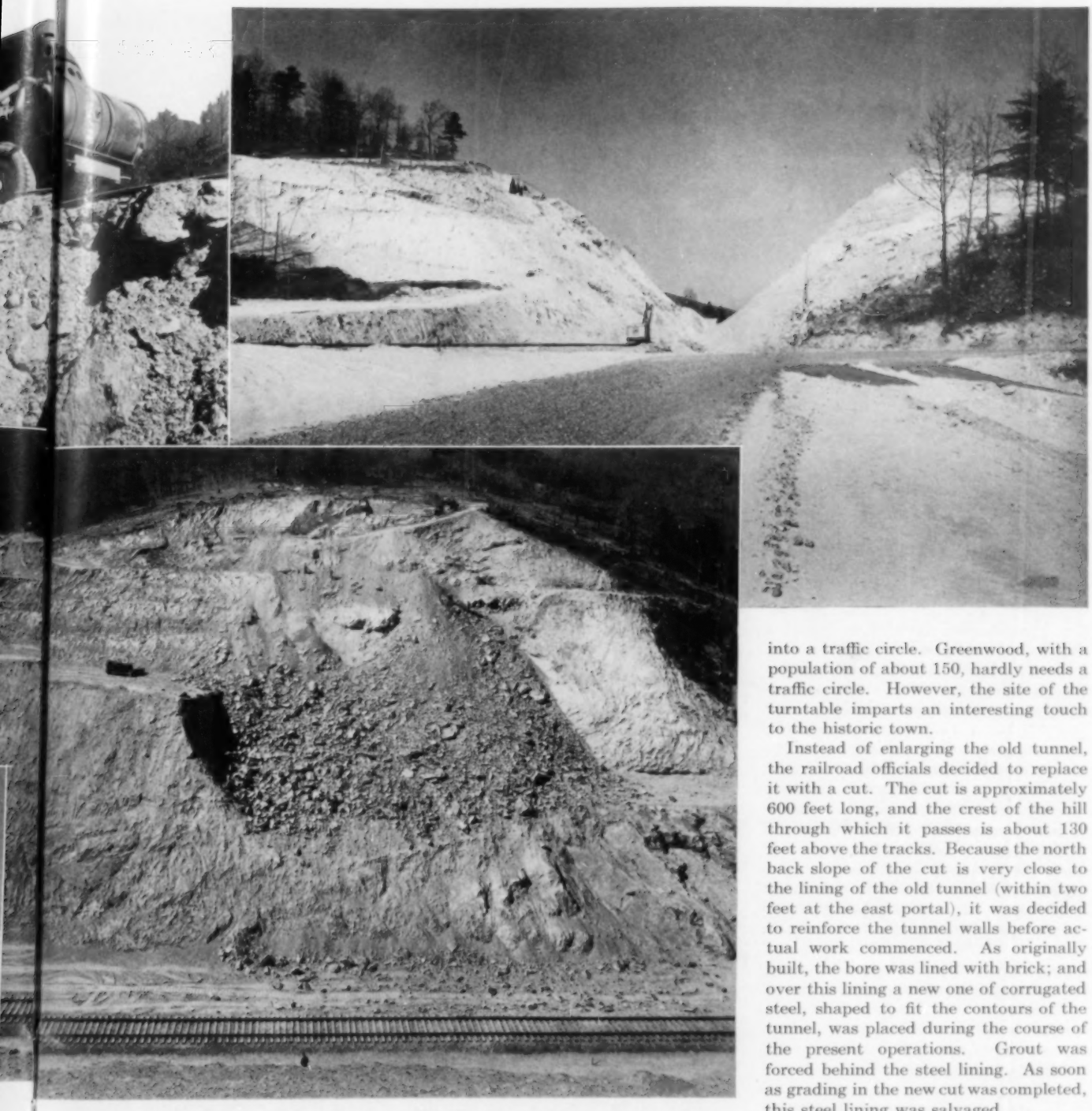
Deep Cut Replaces Old Railroad Tunnel

A. W. Loomis



WHERE THE PAST BRUSHES ELBOWS WITH THE PRESENT

Above is a view of the new cut, looking west, with the east portal of the old tunnel at the right of the tracks. The picture at the lower right shows the west portal with P. L. Graves, resident engineer for the Chesapeake & Ohio Railroad, standing in front of it. The corrugated steel lining that was placed to strengthen the structure during the excavation of the nearby cut is plainly visible. The west end of the cut is illustrated at the extreme upper right. When the cut was made, the north slope was left steep because of the nearness in some places of the tunnel passing beneath it. Later, when service through the tunnel had been discontinued, the work of reducing the inclination of that slope and of benching it was carried out, as shown in the lower view on the next page. One of the Ingersoll-Rand 315-cfm. Mobil-Air compressors that furnished air for operating the rock drills is pictured at the top-center. The cut was excavated, under contract, by Albert Brothers of Salem, Va.



BETWEEN Greenwood and Waynesboro, Va., the main passenger line of The Chesapeake and Ohio Railway Company crosses the Blue Ridge Mountains. This section of the line includes several single-track tunnels varying in length from a few hundred feet to nearly a mile. All the tunnels were built during the period between 1850 and 1858. They were designed by Col. Claudius Crozet, who, before becoming chief engineer of the Commonwealth of Virginia, was an artillery officer in the Army of Napoleon. Inasmuch as these tunnels will not pass some of the larger equipment now in use on the C & O, it has recently been necessary to reconstruct sections of the line. A description of the work on the tunnel between Afton and Waynesboro appeared in the September, 1943, issue of this magazine.

In 1852, at Greenwood, a tunnel 538 feet long was completed, and an interesting relic of the construction still exists there. Greenwood was the terminus of the line during the two years required for building the tunnel, and a turntable was provided so that the locomotives could be turned around before starting their return trip. The turntable is no longer in existence, but the space it occupied has been converted into a traffic circle. Greenwood, with a population of about 150, hardly needs a traffic circle. However, the site of the turntable imparts an interesting touch to the historic town.

Instead of enlarging the old tunnel, the railroad officials decided to replace it with a cut. The cut is approximately 600 feet long, and the crest of the hill through which it passes is about 130 feet above the tracks. Because the north back slope of the cut is very close to the lining of the old tunnel (within two feet at the east portal), it was decided to reinforce the tunnel walls before actual work commenced. As originally built, the bore was lined with brick; and over this lining a new one of corrugated steel, shaped to fit the contours of the tunnel, was placed during the course of the present operations. Grout was forced behind the steel lining. As soon as grading in the new cut was completed, this steel lining was salvaged.

Wagon drills, supplied with air by two 315-cfm. portable compressors, did the drilling for the cut. Hauling was done entirely by trucks and by tractors equipped with trailers. All of the 370,000 cubic yards of material removed was used in a fill that lay slightly to the west. This fill permitted an advantageous relocation of the railroad and the building of a paralleling highway.

Work was started on the cut in November, 1941. Track was laid in the new cut and on the new fill so that service could be started in March, 1943. Meanwhile, grading on the back slopes continued, and this phase of the job was completed in April.

Pioneers in American City Engineering

Roy E. McFee

COL. JOHN MONTRESOR
A photograph of John Singleton Copley's portrait from the collection of the Detroit Institute of Arts.

OVER a fireplace in the Detroit Institute of Arts hangs an eighteenth century portrait of Col. John Montresor, British military engineer, whose professional work covered a large part of colonial America. The portrait, painted by the master hand of John Singleton Copley, early American artist, reveals Montresor in the British uniform of the days before the Revolutionary War. The flaming red coat is trimmed with black collar, lapels, and sleeve bands. Gold buttons ornament both the coat and the black hat. Immaculate white ruffles circle the neck and wrists. The British officer is shown leaning over the top of a driven timber pile, the bark of which seems real enough to touch. In Montresor's grasp is a handbook that is clearly labeled *Field Engin'*. He looks out over his project with the intent, calculating eye of the true engineer.

Painted in Boston just before the revolt of the colonies, this portrait has been placed, appropriately, in the Gallery of Eighteenth Century American Art. In keeping with the period, the floor of the room is of wide boards fastened down with wooden pegs. Around the walls are colonial American sideboards, highboys, chests and mirrors. Thoroughly British, and loyal to his sovereign over long years of service, Montresor nevertheless here looks down upon a completely American environment. Even the artist who painted him was an American of many generations. Moreover, in the center of the room stands a large glass case containing silverwork of contemporary American silversmiths. There are tankards by Copley's kinsmen, Edward Winslow and Samuel Vernon. There are also a teapot, creamer, and sugar basket by the patriot Paul Revere.

But exactly who was Col. John Montresor, and what part did he play in colonial American engineering? John Montresor was born in 1736 at Gibraltar, the son of James Gabriel Montresor, also a British military engineer. The boy received his engineering training from his father, and in 1754 came with his parent to America to join Braddock's ill-fated army. Braddock at once appointed John Montresor as an additional engineer.

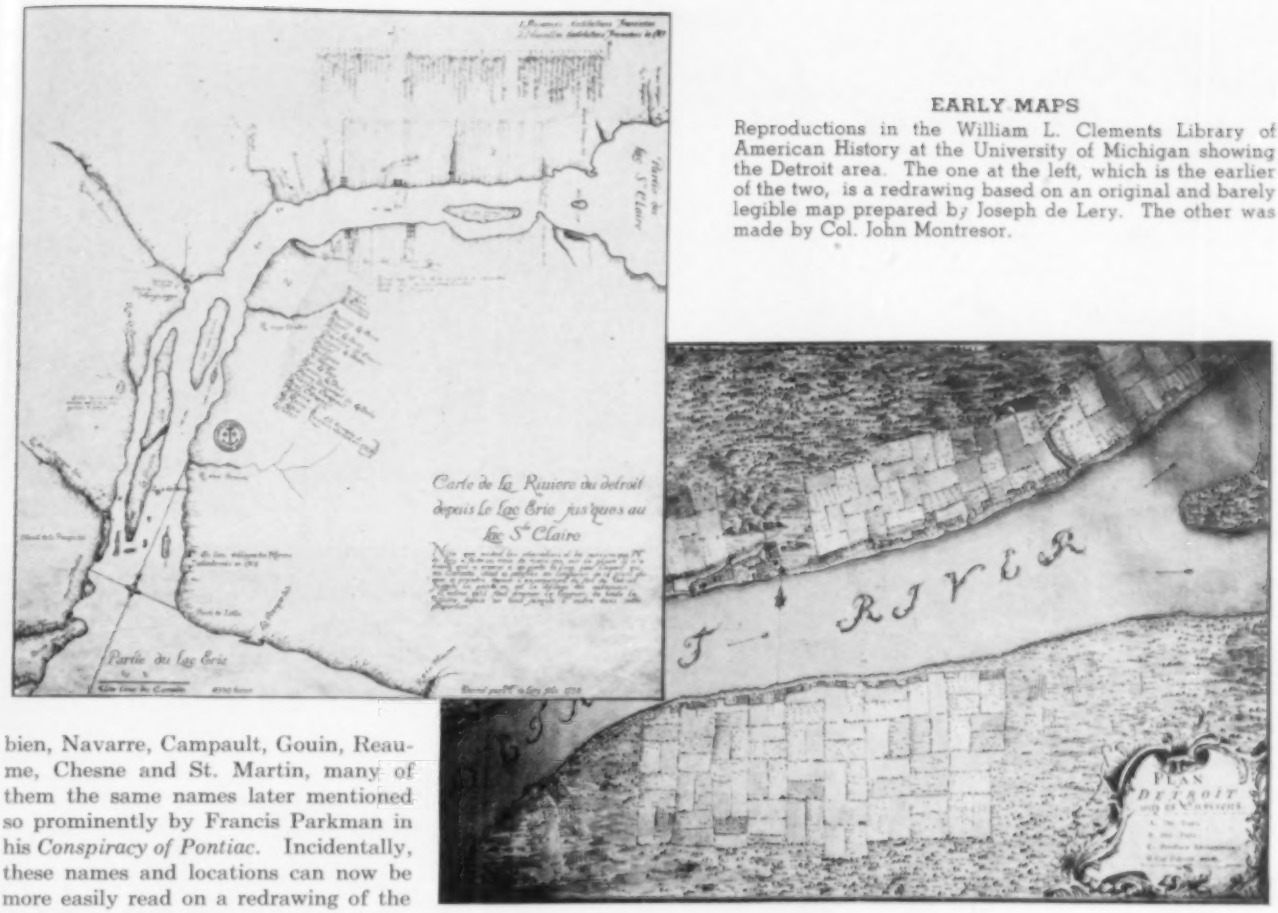
This eighteen-year-old youth was destined, within the next six years, to take part in an astounding number of military campaigns, embracing territory which extended from the forests of western Pennsylvania to the Heights of Abraham. As a military engineer he was wounded at the Monongahela, marched up the Mohawk River, was at Fort Edward on the upper Hudson, and participated in the expedition to Halifax. He then took part in the capture of Louisburg, and was with Wolfe at the historic siege of Quebec.

After 1760, however, there came two years of comparative peace and quiet. Montresor was thus able, for the first time, to turn his genius to more constructive engineering. During this period he was engaged in a survey of the St. Lawrence River, a project which, while military in nature, was to have lasting benefits in peacetime transportation.

But in 1763 came Pontiac's Indian Conspiracy, calling Montresor back to more direct military engineering. Fort Pontchartrain, at Detroit, was being besieged throughout the summer by the Indian forces of Chief Pontiac. Montresor was sent there with men and dispatches for the Detroit commander, Major Gladwin. Although shipwrecked on the shore of Lake Erie and attacked by Indians immediately afterward, he and his party finally reached Detroit and relieved the garrison. At Detroit he enlarged and strengthened the fortifications. After the siege ended he made an excellent map of the Detroit fort and settlement.

There had been other maps of the Detroit area, made by earlier engineers. The first was published in 1703 in Paris by Guillaume de l'Isle, and showed the vast Middle West, with the settlement of Detroit accurately located on the Detroit River. This map was in French. The title was elaborate: "Carte du Canada ou de la Nouvelle France, par Guillaume de l'Isle, Geographe de l'Academie Royale des Sciences, a Paris, 1703." Much later, in 1755, another map was published by Jacques Nicolas Bellin, engineer to the King of France. On it, Fort Pontchartrain was shown in correct location and the straits were marked "Le Detroit." This map was likewise in French. The title was scarcely less elaborate than that of the first map: "Parte Occidentale de la NouvelleFrance ou du Canada, par Mr. Bellin, Ingenieur du Roy et de la Marine, 1755."

In 1752, however, a more detailed map of Detroit had been made by Joseph de Lery. This was a large-scale map of both banks of the Detroit River, on which were shown the names and locations of the French habitants, again in the French language. Here appeared such family names as St. Aubin, Beau-



EARLY MAPS

Reproductions in the William L. Clements Library of American History at the University of Michigan showing the Detroit area. The one at the left, which is the earlier of the two, is a redrawing based on an original and barely legible map prepared by Joseph de Lery. The other was made by Col. John Montresor.

bien, Navarre, Campault, Gouin, Reaume, Chesne and St. Martin, many of them the same names later mentioned so prominently by Francis Parkman in his *Conspiracy of Pontiac*. Incidentally, these names and locations can now be more easily read on a redrawing of the de Lery map in the possession of the William L. Clements Library of American History at the University of Michigan.

The map of Detroit which was made by John Montresor about 1763 was in English. It showed both banks of the Detroit River on a still larger scale. The land subdivisions were indicated, Belle Isle was shown, and the stream was labeled "Detroit River." The topographical symbols were excellent. Capital letters were used to mark "The Town," "Out Posts," "Pondiacs Encampments," and "Captain Dalyells Defeat." The map carried the simple legend "Plan of Detroit and its Environs," and bore the signature of John Montresor.

After Pontiac's Conspirary, Montresor's engineering work was on a still larger scale. First he fortified the portage at Niagara. After a brief visit to England he returned in 1766 as engineer extraordinary and captain-lieutenant. In the next few years his military engineering covered work on the fortifications at Philadelphia, New York, Boston, and the Bahama Islands. Much more in the nature of civil engineering than of military engineering was his surveying of the boundary line between the states of New York and New Jersey.

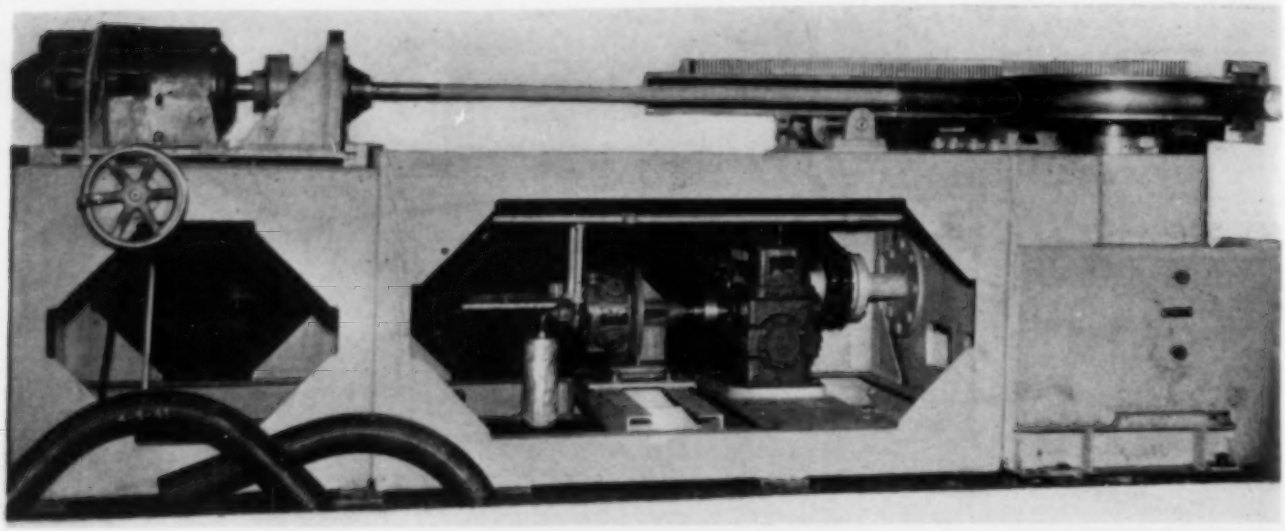
Still, the climax of his career was to come with the breaking out of the Revolutionary War. In 1775, on the eve of the conflict, the British Government made him chief engineer in America, giving him the rank of engineer in ordinary and captain. He was with the British forces in the battles of Lexington and Bunker Hill, and aided in the capture of Long Island. He participated in the struggle at Mud Island, Philadelphia, which was the scene of some of his own earlier engineering construction. Finally, he was British chief engineer at the Brandywine.

The ending of the revolution, with the colonies victorious, closed Montresor's engineering career in America. He gave up Randalls Island in New York Harbor, which he had bought and named Montresor's Island, and where he had lived with his wife and children. He died in England in 1799, far from the scenes of his military activities and major enterprises.

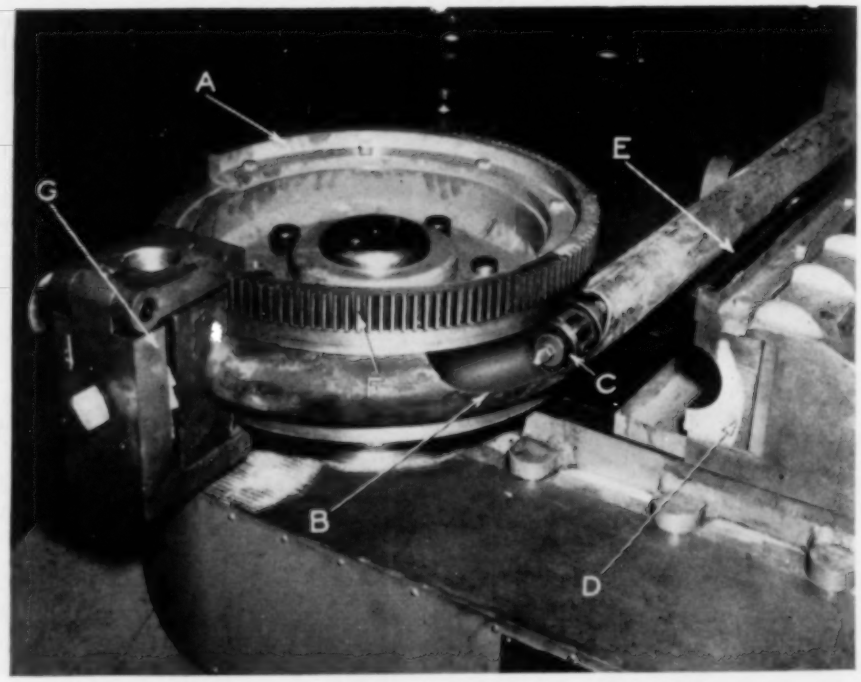
John Montresor brought the first engineering science to vast almost primeval territories in which the drama of empire was being played. His engineering projects were dotted across a thousand miles of trackless woodland, known only to frontiersmen and savage and restless Indians. He provided technical skill for historic campaigns in which great nations clashed for the supremacy of North America. He found settlements mere groups of dwellings within stockades on the very fringe of the forest; and remained to strengthen their fortifications, plan their streets, and finally to record their topographical features on enduring maps.

There have been great advances since these first beginnings in municipal engineering by John Montresor and his few professional predecessors. Yet these men laid the engineering foundations for numerous modern cities in the United States and Canada. Nor have these cities grown so large that their original physical features have become entirely obliterated. John Montresor could still recognize the familiar shore lines, slopes and embankments in many a city of the twentieth century. Joseph de Lery, his map in hand, could read on the street signs of Detroit today the names of the French habitants that he recorded back in 1752.

Documents and canvas signalizing the work of these early engineers in America are to be found in centers of culture extending from Paris, France, to Ann Arbor, Mich. The original maps of de l'Isle, Bellin, and de Lery are in the far-away French archives. The original of Montresor's map of Detroit is in the University of Michigan. And on the gallery wall of the Detroit Institute of Arts hangs the original Copley portrait in which Col. John Montresor is shown peering down over some of his timber fortifications.



Ingenious Pipe-Bending Machine



HOW IT'S DONE

At the top is a longitudinal view of the machine showing the electric-motor drive (top-left) of the spinner mandrel and the housed air-motor installation (center) that provides the power for the bending operation. In the lower left-hand corner are two sections of pipe that have been bent. Directly above is a close-up of the bending mechanism. Wheel *A* is seen with a section of pipe *B* in place. The latter is cut away to show the spinner mandrel *C*. The pipe is clamped tight between the wheel and a sliding form *D*, which is provided with a gear rack *E* that engages a gear segment *F* on the wheel, thus feeding the pipe. As the sliding form is drawn forward by the wheel through their coaction there is no possibility of the pipe being flattened in bending. The gear-and-rack feature also assists in the removal of the finished pipe. This is done by releasing clamp *G* from the bending wheel and letting the machine continue its forward travel.

FOR bending pipe cold without the need of fillers there has been developed a machine known as the Superior Pipe Bender which is being handled by Marine Research Associates, Inc. Two sizes are at present available—Series A for piping from 2 to 4 inches in diameter and Series B for 4- to 9-inch pipe. They are suitable for use in connection with any pipe of approximately standard wall thickness made of ductile metal such as copper, copper-nickel alloy, brass, steel, and iron.

The outstanding feature of the unit is said to be the spinner mandrel which completely fills the pipe and is rotated while bending is in progress. This prevents wrinkling or inside scars and causes the pipe to retain its full sectional area. The mandrel is turned by a long drive shaft that is connected to a geared electric motor and provided with an adaptor so that spinners of different sizes can be used. Bending is done by a wheel that is revolved slowly by an air motor connected to the main shaft by a gear train and speed reducer that assures a reduction of 27,000 to 1, or a large bending torque with a motor of minimum horsepower—3.2 hp. for Size A and 5.2 for Size B.

The air motors are of the reversible type and permit of a wide range of controlled speeds and instantaneous starting and stopping. They have an ample reserve of power, usually operating at a pressure of 35 to 40 pounds per square inch. Where plants are not piped for air, or for service in isolated places, a small compressor will meet the bender's needs. All controls are at the operator's station at the front of the machine and include a push-button switch to actuate the spinner-mandrel motor, a hand-controlled indicator mechanism that regulates the speed of the air motor, a chart that shows the speeds required to give pipes of varying sizes certain radii, and a graduated indicator dial that permits making bends of the desired degree. By actual test with 8-inch copper pipe having a wall thickness of 0.093 inch, the machine is claimed to have effected a time saving, as compared with the conventional method, of better than twenty to one.

Treasures from the Ocean

MANY individuals who habitually "view with alarm" are concerned about the rapid dissipation of our natural resources, particularly minerals. The accelerated demands of the war, say these pessimists, are so depleting our sources of raw materials that we may face serious shortages after the conflict.

Although a great many geologists and mining men probably do not share these views, it is none the less true that our reserves of mineral wealth are not of the Gargantuan proportions that they once were. We are a prodigal nation, and our waste has long been the subject of comment by thriftier peoples the world over. It is interesting, therefore, to consider how our stores might be replenished if the predictions of the alarmists ever do come true.

Part of the answer already exists in the extraction of magnesium and bromine from the sea. There are also large deposits of manganese (an important element in high-grade steel) on the ocean floor. The exact origin of these is unknown, though it has been suggested that they may have been formed by the remains of animal organisms with manganese instead of iron in their tissues.

It is said that the skeletons of many diatoms are finely divided pure silica; that oyster shells are a huge source of pure calcium carbonate. Vanadium is an element concentrated by an ascidian and by a sea slug found off the Cornish coast. Iodine, present in seaweed, has been extracted commercially from its ash; and seaweed itself is often used as a fertilizer because of its high potassium content. It has been recognized, too, that the blood of lobsters and king crabs secretes copper, and that organic copper salts in marine organisms are valuable in the treatment of pernicious anemia. A number of ocean crustaceans are also said to contain arsenic.

We understand that certain types of plant life are capable of extracting gold from the earth's crust, and that some of these plants have been used by Colorado prospectors to locate veins. In view of this phenomenon, it is interesting to speculate on what might happen if seaweed, too, were found to concentrate gold in its tissues. Stranger things have happened. There is, for example, a species of yellow violet that grows only where it can get tin from the soil.

Natural divining rods of this character may yet lead us to the discovery of rich and strategic mineral deposits—deposits that may be of value not only in the prosecution of the war but in the years of the postwar era. Man's resourcefulness and inventiveness know no bounds, and it seems entirely possible that he will, in future generations, turn to the sea for many of the mineral elements that now come from mines.

From Mexico to Costa Rica

DESPITE the war—or, rather, because of it—additional stretches of the much-publicized Inter-American Highway are rapidly emerging from the blueprint stage and are becoming actualities. A recent announcement from Washington states that the road will be open after October 31 for continuous travel from the southern Mexican border to Costa Rica. The completion of this section has been due to some large-scale operations carried out in Central America during the past year. Work on other parts of the project continues to go forward.

Between Mexico and Costa Rica the road crosses some of the most primitive areas of the North American Continent. The completion of this section was speeded by a prodigious amount of pioneer work on the part of U. S. Army Engineers, the object being, of course, to extend communications toward the Canal Zone. This pioneering cost approximately $40,000,000—a staggering sum in itself, but probably not too great when the urgency of the situation is considered. Moreover, we must remember that this money has not been dedicated entirely to military pursuits; for the road will serve as an important international tie when peace returns.

Eventually, the Inter-American Highway will provide an all-weather route from the southern border of the United States to the Canal Zone, a distance of about 3300 miles. Already, 2650 miles of it is traversed by the roadway. The remaining gaps consist chiefly of 400 miles in southern Mexico and about 250 miles in Costa Rica. Both of these gaps will offer serious problems, for the mountainous terrain makes construction difficult.

However, the importance of a continuous highway is fully recognized, not only by the nations of Central America but by our own legislative bodies. Although the war has postponed the immediate attainment of this objective, Congress refuses to abandon its long-range view of the program. It has authorized the spending of $20,000,000 over a 5-year period, plus $12,000,000 for a particularly difficult stretch in Costa Rica.

"After the war," says Edwin W. James of the Inter-American Regional Office, "these new highways will facilitate tourist travel among the Americas. When Mexico completes her sections linking Mexico City with the capitals of Central America, the Inter-American Highway will open to tourist travel by automobile some of the most beautiful and historic country in the Western Hemisphere."

But the benefits of the roadway are even now being realized in tangible fashion. It is believed that completed sections of the highway are stimulating war production in Central America and are aiding the exchange of foodstuffs and other strategic materials between the United States and our good neighbors to the south.

Special Grinder for Carbide Cutting Tools

UNTIL the recent development of an automatic machine for grinding the top faces of carbide cutting tools the work called for the services of specially trained operators. Now it comes under the category of unskilled labor because the equipment is said to do everything except insert the tool in the holder and remove it when finished. To appreciate what this means it should be mentioned that the work involves, first, the application of the tool against the grinding wheel with enough pressure to do a good job, for more than that will overheat the tip and cause thermal cracking. Second, the movement of the tool across the wheel must be continuous to avoid localized overheating; and, third, grinding must always be done toward and not away from the cutting edges so as not to damage the latter by breaking out small particles.

HARD WORK SIMPLIFIED

The operator in the foreground is removing a ground tool from one of two arms that characterize the new grinder. Each arm is pivoted near the center and is connected at the lower end to a 2x6-inch pneumatic cylinder with a stroke of approximately 5 inches and using air at about 40 pounds pressure. When actuated, the arm holding the tool is pulled down to a horizontal position against the grinding wheel, as shown at the right. After a predetermined number of seconds the arm is automatically released and pulled back to the loading position by a coiled spring. While one tool is being ground another can be mounted ready for grinding, or each arm can be used independently, as it is a separate unit.

The new single-purpose grinder was developed by the Edison (Hotpoint) General Electric Company and is being manufactured on subcontract for Carboloy Company, Inc. Its speed of operation and the high-grade finish obtained with it are attributable to the facts that the grinding wheel not only rotates but also oscillates while the tool is kept stationary at the correct angle, and that the tool is held against the wheel under controlled air pressure. The construction of the machine is such that low pressure is first applied to bring the tool against the wheel for the removal of jagged edges. Then the pressure automatically increases until it reaches a predetermined point, at which it is maintained until the tool is finish ground. The time cycle is set by means of a simple dial control.

An added feature of the new unit is the substitution of metal-bonded, diamond-impregnated wheels for the former resinoid type that has a much shorter service life. This has been made possible by the higher pressures with which the tools can now be held against the wheel—pressures that diamond-impregnated wheels require for efficient operation and that are not obtainable by the older method. It is claimed that the machines have paid for themselves in a few months' time on the score of wheel cost alone.

While designed primarily for use in connection with carbide tools, the principle upon which the grinder is based has been applied to a limited extent but with equal success to machines for grinding the ends of high-speed-steel tools. In addition, others are being built at the Edison General Electric plant for the mass production of standardized Carboloy cemented carbide tools, and work is underway on a general-purpose grinder of the same type.

Computing Coal Requirements by Slide Rule

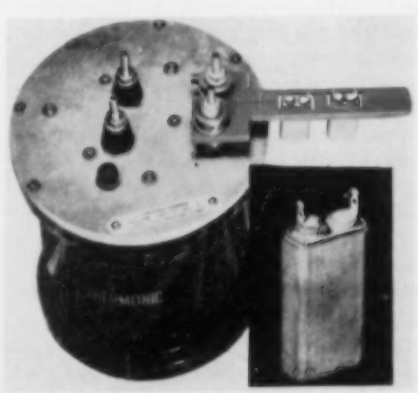
AN INGENIOUS fuel computer in the form of a circular slide rule has been designed by the U. S. Corps of Engineers for calculating the fuel requirements of Army posts. It makes use of the factors of known floor area to be heated, fuel allowance per unit area, and number of "degree days" normally occurring in the locality for the season—weather records, as far back as they exist, having been checked to obtain that information. By means of the computer, post engineers responsible for keeping troop communities adequately heated may order their coal supply far enough ahead to release what remains for public use. It also provides a handy check against above-average consumption of fuel at any post or group of buildings within a post.

Another device developed by the U.S. Corps of Engineers is the fuel economizer for coal-fired heating stoves. It has been estimated that this gadget has increased the heating capacity of existing Army installations by more than 50 per cent. An additional $5,000,000 has been saved by training certain enlisted men to keep the stoves in good operating condition. The total floor space at all our Army posts, including warehouses, hutments, and barracks, now reaches the astronomical figure of 1,180,243,710 square feet!

Soldering by Induction Heating

ONE of the newest developments in the field of induction heating is the soldering of covers on condenser cans. By the new method, eight condensers, with the flux applied, are set in a fixture directly above which is a copper work coil shaped to accommodate the objects to be heated. The respective joint areas of the cans then receive a ring of solder, after which the fixture is raised and a Thermonic induction generator is energized to heat those areas. As soon as the current is switched on by the pressure of a button, a timer begins its cycle, and in 2½ seconds automatically shuts off the power. When the joints have cooled, the cans, completely soldered, are lifted from the fixture. For quantity production, a 2-station coil arrangement is used. This permits one lot of eight cans to heat and cool while loading another.

According to the Induction Heating Corporation, in whose laboratory the developmental work was done, the substitution of Thermonic induction heating for the soldering iron has, in this case, led to a saving in soldering time of more than 99 per cent. In addition, the elimination of hot irons and of the human equation has resulted in comfortable working conditions, in a reduction in operating costs, and in uniform joints.



SOLDERING SET-UP

This picture shows the energizing transformer with the projecting work coil designed to solder condenser cans of varying sizes. The coil is interchangeable so that one transformer can be used to braze or solder work that differs widely in form.

Industrial Notes

Entire houses, including piping, are being built in Rhodesia of domestic asbestos-cement.

Copper and ammonia are being recovered in Europe from the waste spinning liquors of the cuprammonium-rayon process. The method, reports *Foreign Commerce Weekly*, is in a semiexperimental stage and involves passing the liquors over a new type of synthetic-resin exchanger.

Scotchlite is the trade name of a new material for defining passageways and making obstructions visible in the dark. It is a product of the Minnesota Mining & Manufacturing Company and consists of a flexible synthetic-resin sheet covered with small glass beads forming a reflecting surface. It is cut to fit by the user, can be lettered, and comes in several colors—white and yellow for traffic-control purposes, and silver for signs and markers.

A liquid adhesive suitable for binding metal to rubber, plastics, leather, or wood, or layers of the same kinds of materials, is being offered by the U. S. Stoneware Company under the name of Reanite. Applied by air brush, spray, or dipping, it is allowed to dry for an hour, after which the sheets are joined under heat and pressure. It is said to withstand vibration and to be unaffected by water and temperatures ranging from –40 to 300°F.

The addition of a newly developed powder to the water in a spray booth provided with a water curtain or with a sump is said to prevent breaks in the curtain and the formation of scum that interferes with the recovery of overspray. The resultant sludge is smooth and disperses readily in reclaiming the paint. The powder is called Defloccula-tor and is made by Turco Products, Inc.

By using salt water for grading and surfacing operations, a contractor building giant runways at a western air base was able to keep the work going throughout the winter months. He set up a special brine plant and added 1.84 pounds of salt per gallon of water to prevent it from freezing. It took 59,950,000 gallons of water and 55,154 tons of salt to do the job.

Making up payrolls is a troublesome job these days if the paper-and-pencil method is relied upon. However, short cuts are available, and among these is the Deduct-O-Graph worked out by the George S. May Company, business engineers, 2600 North Shore Avenue, Chicago, Ill. The calculator automatically indicates the tax deduction for each employee when the proper settings are made as to the marital status, wage scale, and pay period. It has been found to be both accurate and speedy in tests made by payroll officials. Any firm can obtain a Deduct-O-Graph free of charge by writing the request on its letterhead.

For use in explosive atmospheres, Lewis-Shepard Products Inc., manufacturers of materials-handling equipment, has introduced a stacker powered by an industrial air-motor hoist. Except for this unit, the portable elevator is built on the same general lines as the company's well-known electric stacker and has a capacity range of from 250 to 5000 pounds. The machines are easily maneuverable and permit piling sacked, baled, and packaged goods, etc., from floor to ceiling with dispatch, safety, and facility. The motor is operated with air at from 60 to 100 pounds pressure. Hoisting and lowering are controlled by cable or by handles that permit running the elevator from either side and at any

CHECK THESE NAYLOR PERFORMANCE ADVANTAGES

- Always accurate in diameter.
- Concentric ends match correctly.
- Easier to install.
- Holds true cylindrical form.
- Stays tight and leakproof.
- Stronger — safer.
- High salvage value.
- Light weight saves steel.
- Cuts maintenance costs.
- Saves money.

Sizes: 4" to 30" in diameter—all types of fittings, connections and fabrications.

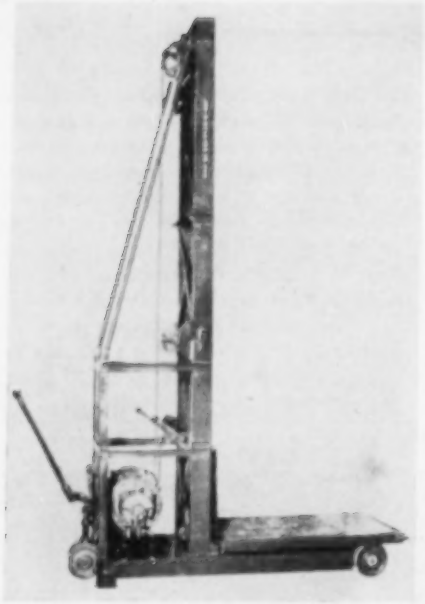
POST-WAR VENTILATING JOBS CALL FOR NAYLOR LIGHT-WEIGHT PIPE

There are three sound reasons why Naylor is the preferred pipe for push-pull ventilating service. It is light in weight. It is leaktight. And it is stronger, thanks to the exclusive Lockseam Spiralweld truss that runs the length of the pipe.

Add to these advantages the practical savings of Naylor lightweight pipe and you can see why so many experienced operators depend on this distinctive pipe for permanent as well as temporary ventilating lines.

Naylor
LOCKSEAM
SPIRALWELD PIPE

NAYLOR PIPE COMPANY
1245 East 92nd Street
Chicago 19, Illinois



SAFE AND ADAPTABLE

This stacker is designed for service in places where there is danger of explosion and is operated by an Ingersoll-Rand Type C air-motor hoist using air at from 60 to 100 pounds pressure. Built to telescope, the reach of the elevator can be easily changed to permit storing under sloping roofs or wherever the height varies.

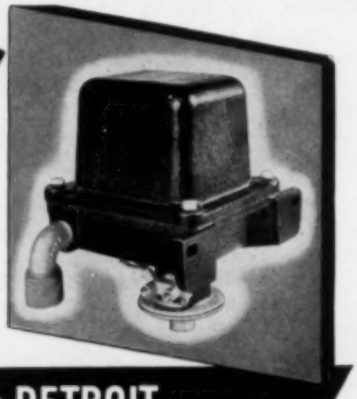
up and down speed within its limits. The former varies with the load and air pressure, while the platform can be lowered at a maximum speed of approximately 100 feet per minute. When the hand is removed from the control the air motor stops and the holding brakes are automatically applied. Aside from the safety element in explosive atmospheres, the air-powered stacker has an advantage over the electric type in the matter of speed control.

How improved steel-mill practices have increased production is brought out by the following comparative figures. In 1918, a modern steel plant tapped 110 net-ton heats, had a daily output of 194 tons per furnace, and a fuel consumption of 6,600,000 Btu. per net ton of ingots. Today, 169 net-ton heats are tapped, the daily output per furnace is 310 tons, and the fuel consumption per ton of ingots is 3,700,000 Btu.

In the improved type of Champion air-hose reel illustrated, the winding mechanism is completely enclosed. The housing consists of two sheet-metal stampings one of which may be removed

for inspection or hose renewal. Unreeling is controlled by a motor spring, and the hose may be stopped automatically at every half revolution of the wheel, if desired. Rewinding is effected by a brake energized by equalized governor weights. Model ES-3, the one shown, is designed for ceiling mounting and has a ball-bearing swivel arm which permits the housing to swing in either direction with the hose. Another unit is built for ceiling, wall, or floor mounting. Standard reels carry 30 feet of air hose.

HERE IS AN *Explosion-Resisting* PRESSURE SWITCH

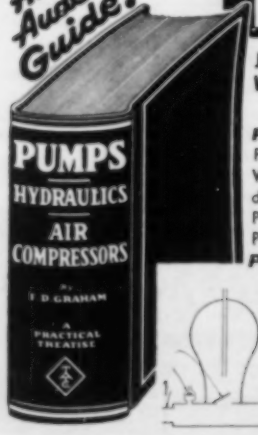


● The **CLASS 9013 TYPE AR** switch is built for use in Class I Group D hazardous locations. Top pressure 225 lbs.—standard air compressor settings—with or without release valve. Ratings are 2 H.P. 110 V., 3 H.P. 220 V. single phase and 5 H.P. 220-550 V. polyphase.

SWITCH • PROTECT • REGULATE • DO IT ALL WITH SQUARE D

SQUARE D COMPANY • REGULATOR DIVISION • DETROIT

An Audel Guide!



PUMPS-HYDRAULICS-AIR COMPRESSORS

JUST OUT! 3 BOOKS IN ONE—OVER 1650 PAGES, 1654 ILLUSTRATIONS, WITH QUESTIONS AND ANSWERS. COMPLETE PRACTICAL CONCISE INFORMATION FOR ALL ENGINEERS AND OPERATORS.

***PART 1*—PUMPS—850 Pages:** All types—Centrifugal—Rotary—Reciprocating Pumps: Their Theory, Construction, Operation and Calculations. Air and Vacuum Chambers—Power Pumps—Air Pumps—Jet Condensers—Surface Condensers—Condenser Auxiliaries—Condenser Operation—Calculations—Cooling Ponds—Cooling Towers—Water Supply—Hydraulic Rams—Special Service Pumps—Automotive Fire Pumps—Dredges—Codes. 942 Illustrations.

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Send postpaid AUDELS PUMPS, HYDRAULICS, AIR COMPRESSORS ($4). If I decide to keep it, I will send you $1 within 7 days; then remit $1 monthly until purchase price of $4 is paid. Otherwise, I will return it promptly.

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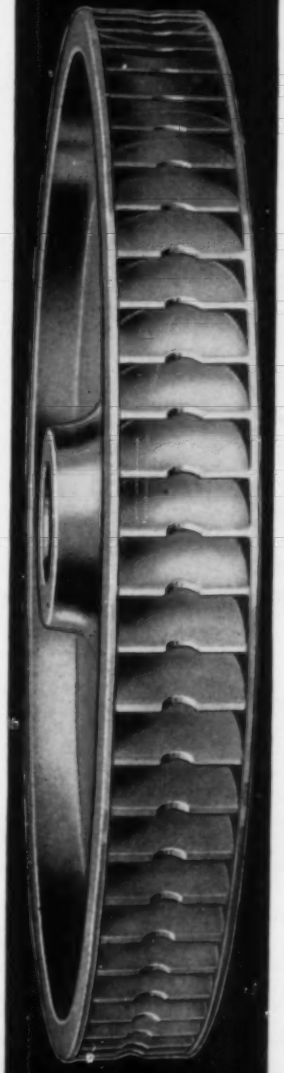
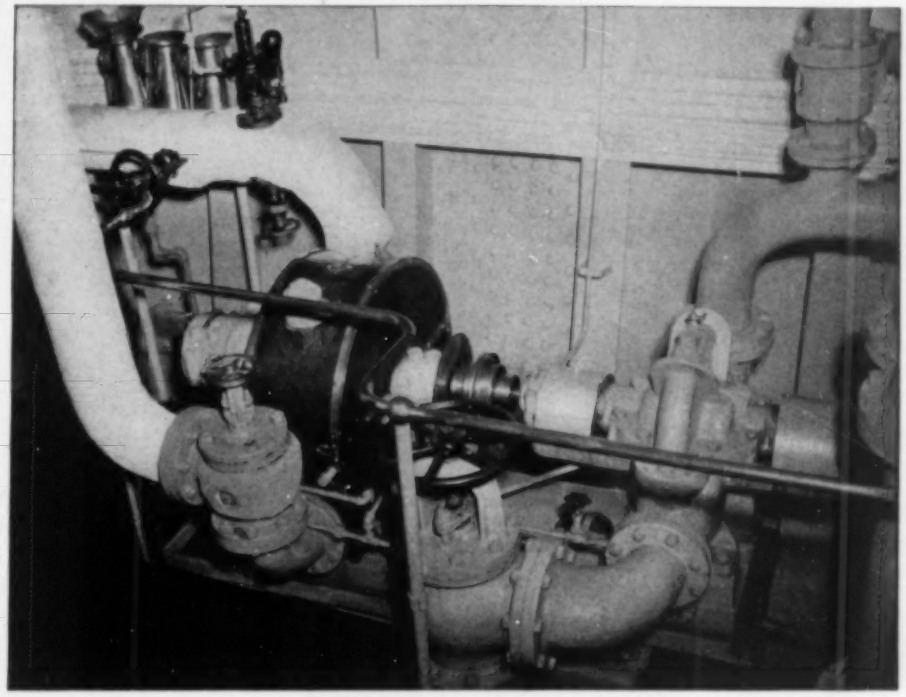




Above—50 H. P. Terry Solid Wheel Turbine driving Fire and Sanitary Pump on recently completed merchant ship. Steam condition: 450 lbs. 750° TT - 10 lbs.

FOR AUXILIARY DRIVE — THE TERRY SOLID WHEEL TURBINE OFFERS MANY ADVANTAGES

FROM THE SMALLEST TO THE LARGEST, THESE RELIABLE TURBINES HAVE—

- ★ Indestructible one piece wheel.
- ★ Large radial and axial clearances.
- ★ Double rim protected blading.
- ★ Individual nozzle control.
- ★ Dependable and durable governor.
- ★ Heavy dust-proof bearing and governor housing.
- ★ Independent overspeed trip with separate valve.
- ★ Sturdy casing design.
- ★ Strong and easily inspected steam strainer.
- ★ Truly accessible construction, which makes inspection of the interior parts a simple matter.

FOR FULL DETAILS ASK FOR BULLETIN S-116.

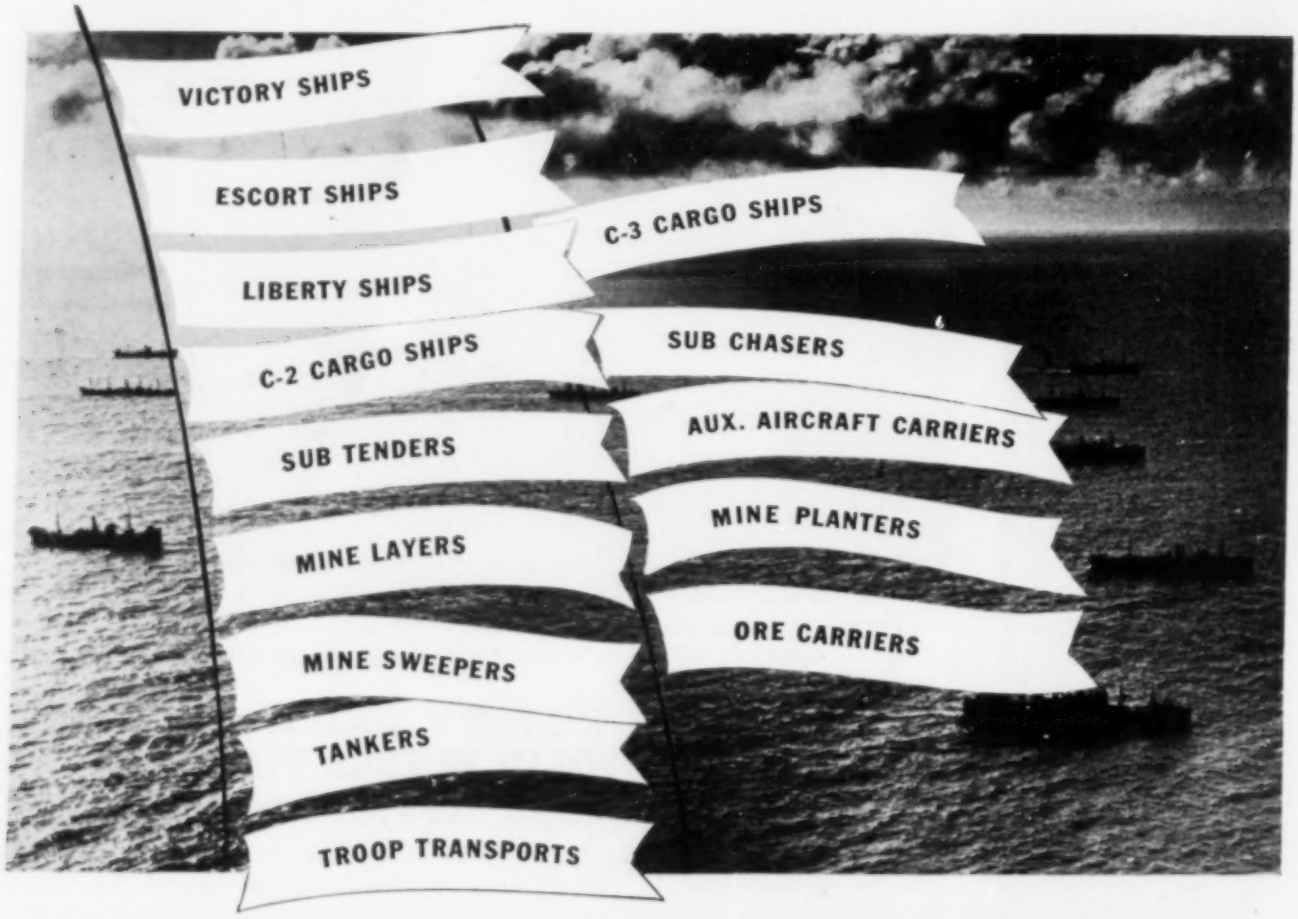
T-1148

THE TERRY STEAM TURBINE COMPANY

TERRY SQUARE, HARTFORD, CONN.

Ships that sail the seven seas...

Are powered by C-E boilers!

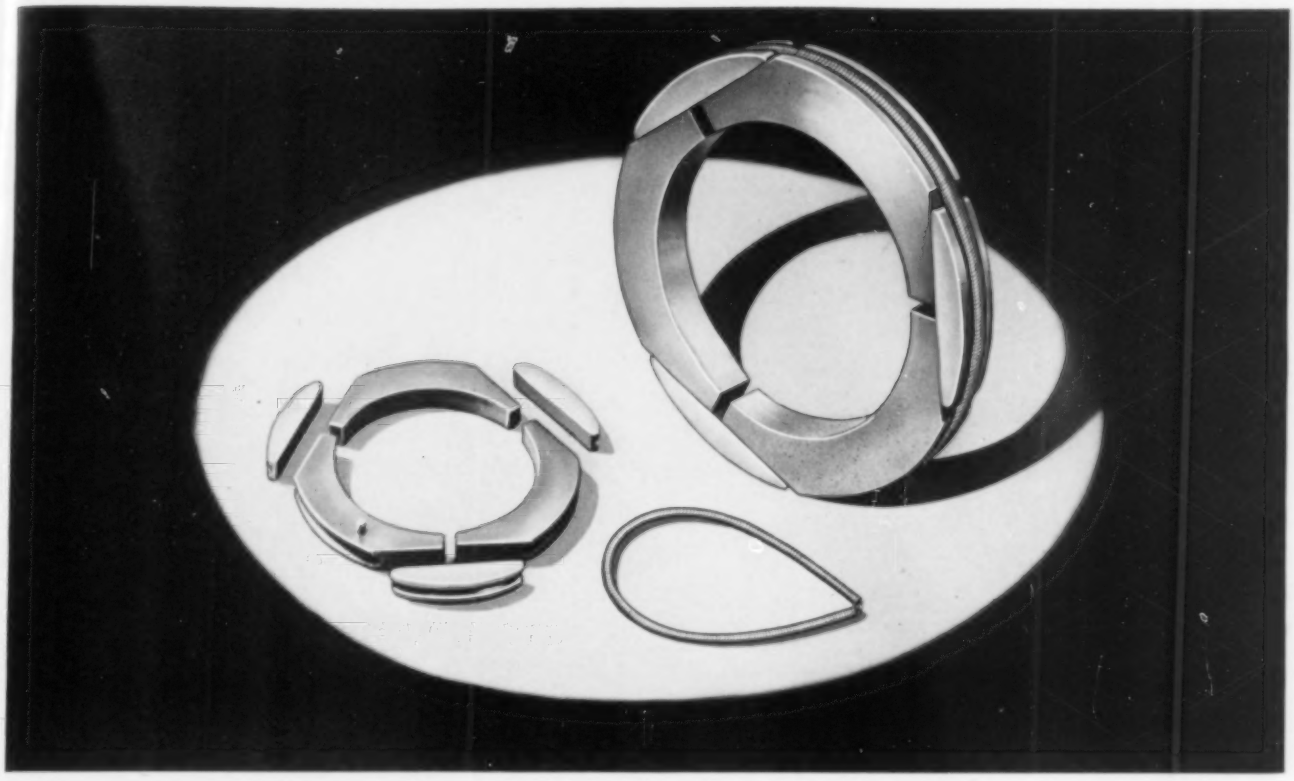


★ This list of merchant and naval vessels indicates the large part assigned to Combustion Engineering in the greatest shipbuilding program of all time. All of these classes of ships are included in contracts for boilers awarded to C-E during the past two and a half years – but even more impressive than their variety is their volume, the principal part of which is represented by the six types of cargo ships listed. When present contracts are completed, an aggregate of over 12,000,000 dead weight tons of cargo shipping will be powered by C-E Boilers. This is in excess of the dead weight tonnage of our country's entire pre-war merchant fleet.

In a war where so much depends on shipping, C-E employees from top to bottom are grateful for the opportunity of making so large a contribution to the vital task of keeping American ships moving through the seven seas. A-743

COMBUSTION ENGINEERING

200 Madison Avenue, New York 16, N. Y.



MODERN... *designs and materials*

Each set of COOK'S Metallic Packing is designed to suit the specific application. The style of packing ring and ring material to be used in each case, are determined by many variables, a few of which are pressure, temperature, nature of gas, lubrication, rod diameter, and rod material.

Obviously with so many variables there is no universal packing ring. Take rod diameter for example. For a fixed set of conditions, one style of ring will serve best on a small diameter rod, while a different style gets the call for a large rod. The nearest approach to a universal ring is COOK'S Type "E" shown above, while below are a few other types.

These are just a few of the many style rings engineered by COOK during the 55 years COOK'S Packings have served the builders and operators of compressors and engines.

Similarly COOK, unique in having its own foundry, has developed many exclusive materials including—COOK'S GRAPHITIC IRON in steam mix, compressor mix and a wide range of alloys, all with COOK'S exclusive "Tinized" surface treatment if required—COOKMET in plastic, semi-plastic and other bronze compositions including white bronze (Babbitt)—in addition, non-metal materials, such as Carbon and Bakelite, either plain or graphitized, are frequently used.

Here at COOK, too, you will find the "know-how" and up-to-the minute practical experience in all kinds of packing applications to give you authoritative aid in selecting the right packings for your particular equipment and operating conditions.

So bring your packing requirements and problems to COOK. The nearest office will give you prompt, efficient service. You will be in good company, for all leading engine and compressor builders use COOK'S Packings. When you order new equipment, make sure you get the genuine by specifying COOK'S.

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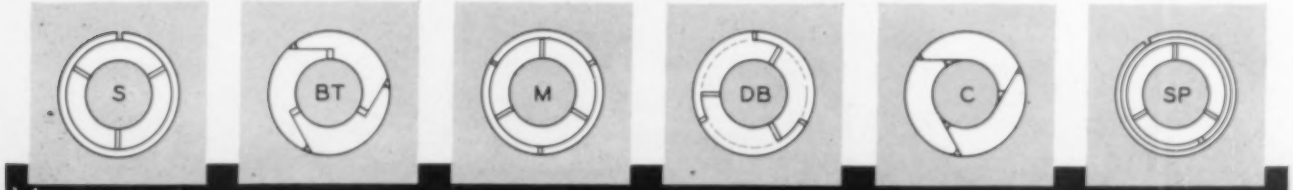
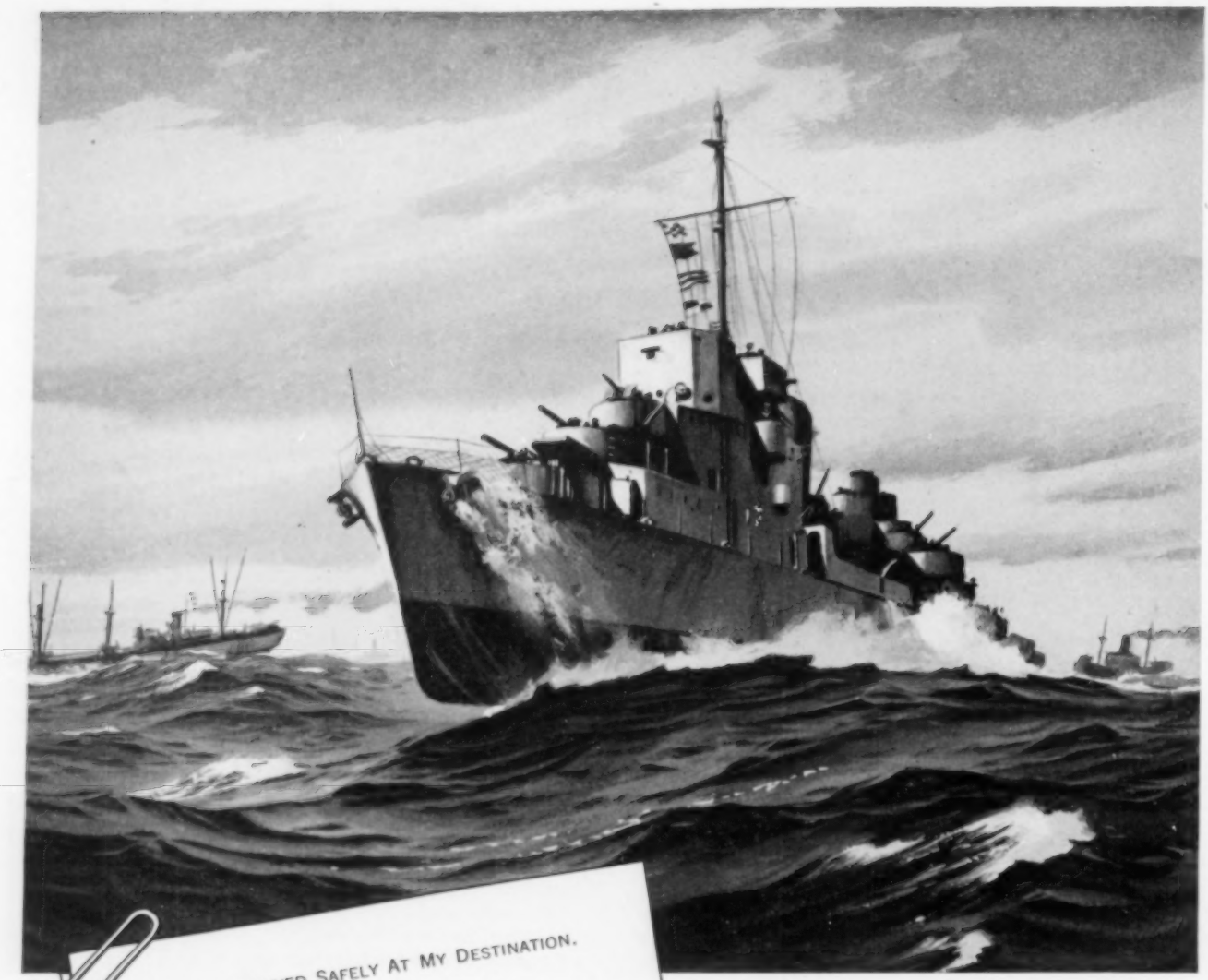


"Sealing Pressures Since 1888"

COOK'S METALLIC PACKINGS



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To build pumps, condensers, and compressors for the Navy's destroyer escort vessels and other warships, is our job. We are proud of it.

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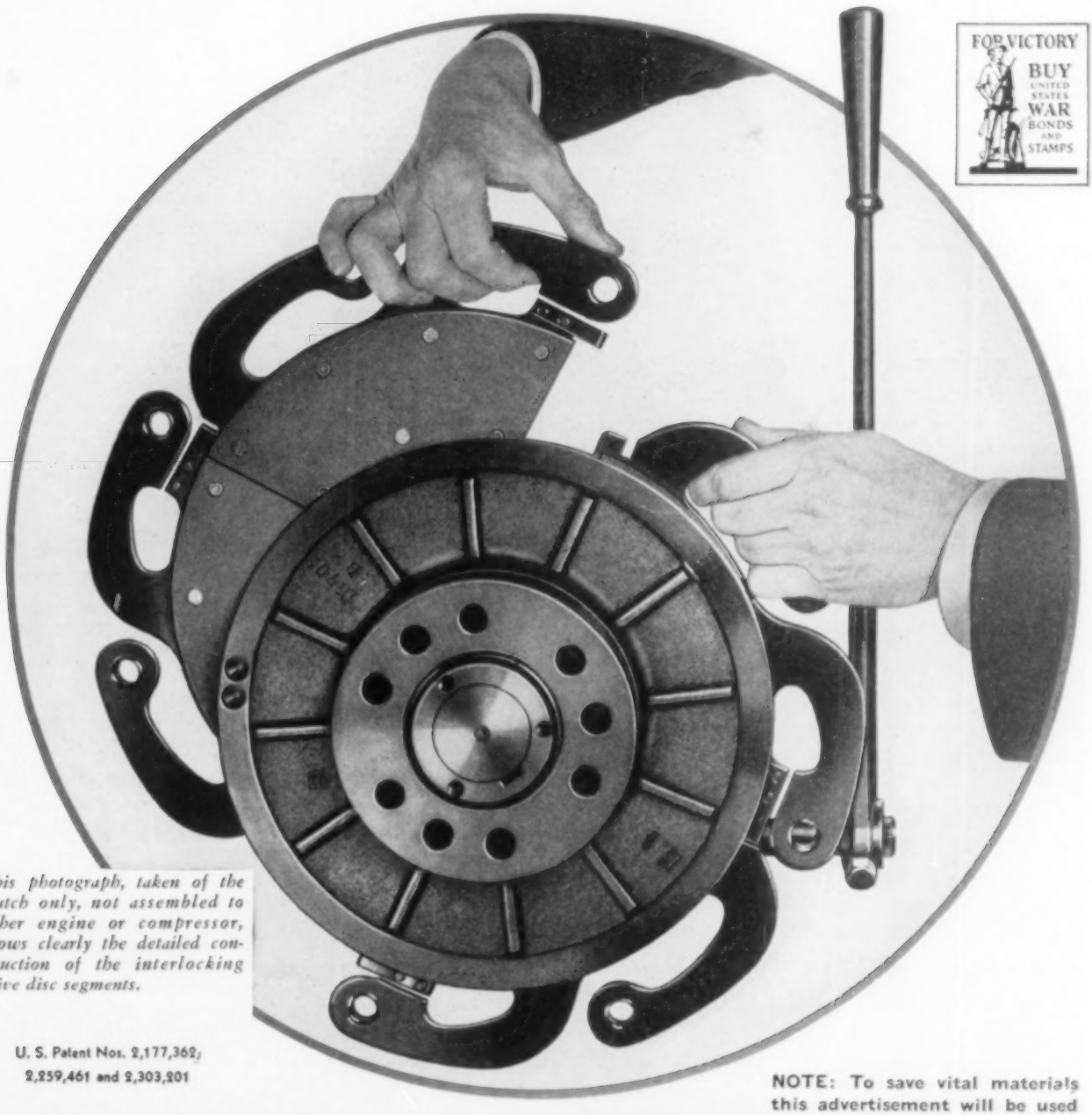
FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

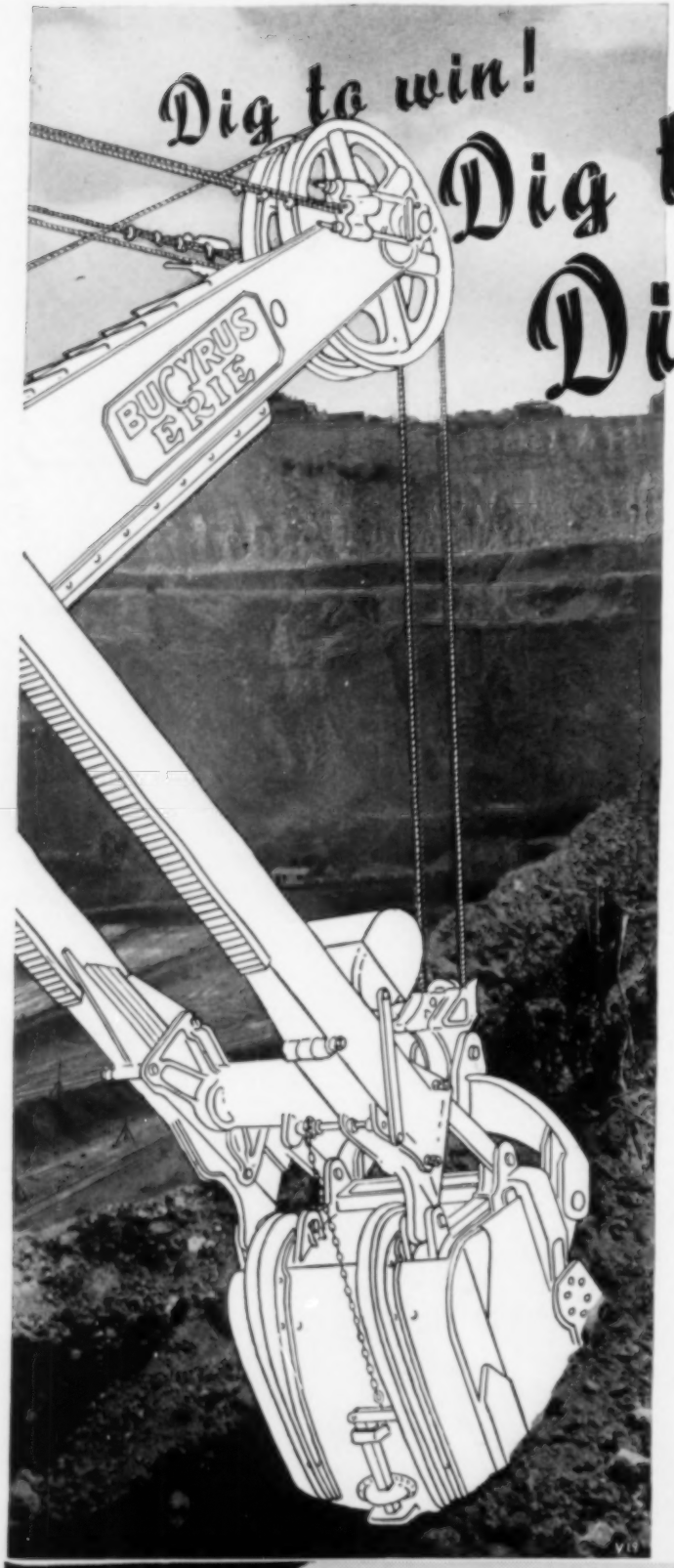
This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

U. S. Patent Nos. 2,177,362; 2,259,461 and 2,303,201

NOTE: To save vital materials this advertisement will be used for "the duration."

C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin



Dig to win!

Dig to win!

Dig to win!

This is a war of industry—to win, every machine must produce faster than ever before. Here are some suggestions that may help you dig faster so Uncle Sam can win faster:

1. Use two truck spot where possible.
2. Spot in line with arc of swing.
3. Spot so load swings over from rear of truck. Don't swing over cab.
4. Swing out from bank as soon as dipper or bucket is fully loaded.
5. Keep swing short . . . spot hauling equipment in close.
6. Try to get a full dipper or bucket every pass, as well as to fill every truck or car, but do not overload.
7. Keep close to your digging — don't "stretch" to reach it.
8. Watch your lubrication to avoid maintenance. Watch your maintenance to avoid lost time.
9. Keep that steady pace which means no slowdown at end of shift.

Bucyrus-Erie

SOUTH MILWAUKEE, WISCONSIN, U. S. A.

NO NEED to tell railroad maintenance men how vitally important track upkeep is these days; this is one of your most pressing problems.

But thanks to the modern equipment that is available, this and other maintenance difficulties consistently are being overcome.

Shown in the photograph is an Ingersoll-Rand Model KRC-16 Crawl-Air Compressor equipped with Timken Tapered Roller Bearings on the compressor crank shaft, operating 16 I-R MT-3 Tie Tampers with a full crew.

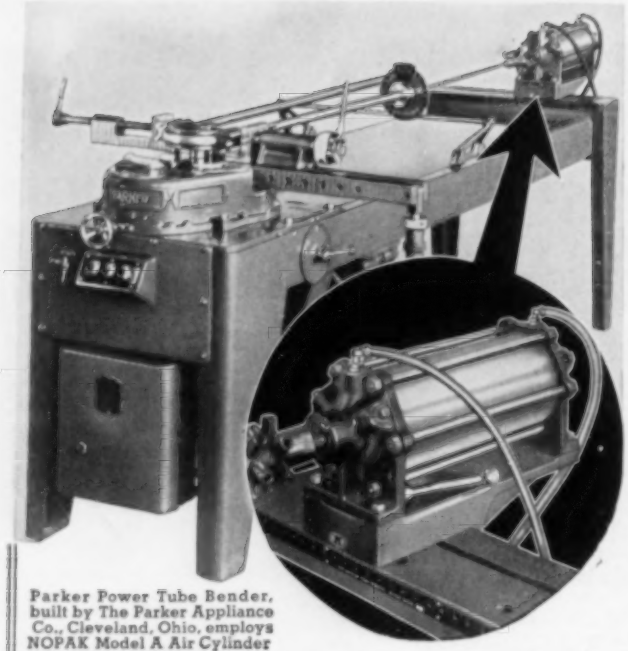
The use of Timken Bearings is a strong factor of performance, endurance and economy in all kinds of railroad equipment—from modern main line steam locomotives and streamlined trains to section motor cars and trailers. Make sure you have them in the new equipment you buy, wherever wheels and shafts turn. The Timken Roller Bearing Company, Canton, Ohio.

Post-war competition will be tough. Meet it and beat it with redesigned equipment, using more Timken Bearings.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



Parker Power Tube Bender, built by The Parker Appliance Co., Cleveland, Ohio, employs NOPAK Model A Air Cylinder to extract mandrel.

NOPAK Cylinder Power

Extracts the Mandrel on Tube Bending Operation

Before tubes or pipes are bent on Parker Power Tube Benders, a mandrel is inserted to prevent crimping at the point of bend. After the bending operation, this mandrel must be extracted without loss of time so that the machine can function at top efficiency.

The powerful pull required to extract the mandrel is supplied by a NOPAK Model A Air Cylinder. The diameter and stroke of the cylinder depends upon the size and capacity of the machine on which it is used. Speed, strength, stamina and uniform pulling power are the basic requirements of air cylinders employed on Parker Power Benders.

This application of NOPAK Cylinders may suggest how you can use NOPAK Cylinder Power to step up certain operations on the machines you build for resale, or use for production in your own plant.

Write for Illustrated Bulletin No. 82A.

NOPAK 2-, 3- and 4-Way Valves provide positive, precision control of Air and Hydraulic cylinder power. Hand, Foot and Solenoid Operated.

GALLAND-HENNING MFG. CO.
2759 SOUTH 31st STREET • MILWAUKEE 7, WISCONSIN

Representatives in Principal Cities

NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

A 4180-½

RELY UPON

Ask the first KOH-I-NOOR user you meet, and then ask a hundred more, and you will get the same unfailing answer, "KOH-I-NOOR can be relied upon to give you definite protection from all lead pencil troubles."

Throughout the fifty-odd years the KOH-I-NOOR pencil has been on the market, we have, through constant research, painstaking effort and strict adherence to material specifications, supplied critical users with a drawing instrument of superlative quality.

Rely upon KOH-I-NOOR

1700 TECHNICRAYON PENCILS with small diameter lead, slightly soluble in water, are manufactured in 30 colors.

SEND FOR FREE BOOKLET NO. 19

KOH-I-NOOR
PENCIL COMPANY, INC.
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Conserve tools by using only clean, dry air

Contamination in compressed air lines builds up maintenance charges, impedes work and shortens the life of tools—such as drills, hammers, tampers, concrete vibrators, paving breakers, pile drivers, impact wrenches, air-driven pumps and hoists.

An Aridifier on the air line thoroughly and continuously removes moisture, oil and dirt by the correct application of centrifugal force. Only clean, dry air is delivered to the tools. It pays for itself many times over in reduced maintenance and increased production.

Write for Bulletin 543—"Aiding War Production with Clean, Dry Air."

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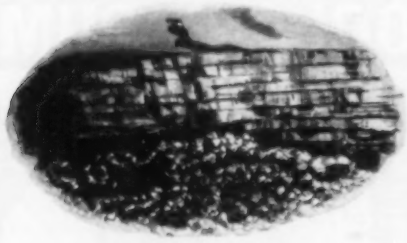
Engineering Representatives in Principal Cities

The ARIDIFIER
Dries and Cleans Compressed Air

TAMPTITE* an answer to manpower shortages

Saves Time, Labor

Without changing your method of operation, Hercules Tamptite saves you time, labor, and expense. You drill your holes the usual way. You use your regular grade and size of Hercules explosive. And you tamp the charge in the usual manner. Everything is the same except that Tamptite permits faster loading of holes, and eliminates the wasted time and trouble of slitting cartridges.



Better Breakage

When you tamp a Tamptite cartridge, the dynamite expands but remains within the wrapper. This fills the bore hole snugly, leaves little air space, concentrates the charge where it is most effective. Naturally, the result is better breakage of the ore or rock and faster mucking, easier handling.

Five Types

Your customary grades and sizes of Hercules explosives—Gelamites*, Hercomites*, Extra Gelatins, Gelatins, and Extra Dynamites—are all available in Tamptite cartridges. To get the greater efficiency of the Tamptite cartridge, specify Hercules on your next dynamite order.

*Reg. U. S. Patent Office

HERCULES EXPLOSIVES

HERCULES POWDER COMPANY
INCORPORATED

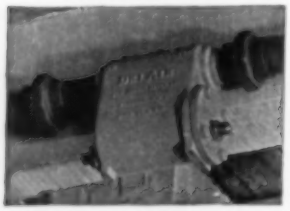
932 KING STREET, WILMINGTON, DELAWARE

DEPENDABLE PNEUMATIC SERVICE

WHEN EQUIPMENT IS PROTECTED BY

DRIAIR

A COMPLETE SELF-CONTAINED UNIT



DriAir may be installed by suspending it from the piping without any other support.

A typical installation showing DriAir standing on the floor next to the wall.

● The answer to many problems which arise in various applications of compressed air, DriAir speeds production by separating and automatically ejecting the condensed water and oil from the air. DriAir collects dirt and rust from the air lines and delivers clean dry air to the tools, hus reducing wear and prolonging their life. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent. Copy of Bulletin DA fully describing the operation of DriAir sent on request; write today.

NEW JERSEY METER COMPANY

PLAINFIELD, NEW JERSEY

THE *Safe* WAY TO POUR Babbitt!

Use Babbitrite, the proven, time-tested babbitt retainer instead of make-shift materials. Eliminate costly time-consuming blow-outs, the danger of injury from hot molten metal. Babbitrite is moisture-proof, is not affected by heat and will not harden. Comes ready-for-use, requires no mixing and can be used over 100 times.

Write for liberal sample.

Babbitrite — AS NECESSARY AS THE LADLE

BABBITT RETAINER

●

PRODUCTS MFG. CO.

517 E. Buffalo St. • MILWAUKEE 2, WIS.

A 4144-¼

COOLANT PUMPS

A TYPE FOR EVERY NEED

¾ and 1 inch sidewall-mounted type for capacities to 50 gpm and heads to 20 ft.

Horizontal type for capacities to 60 gpm and heads to 25 ft.

¾ and 1 inch immersion type for capacities to 60 gpm and heads to 40 ft.

1¼ inch sidewall type for capacities to 60 gpm and heads to 25 ft.

1½ inch immersion type for capacities to 150 gpm and heads to 125 ft.

Low-submergence, sidewall type for capacities to 60 gpm and heads to 25 ft.

9-251

Ingersoll-Rand

CAMERON PUMP DIVISION

11 Broadway, New York, N. Y.

SIX REMINDERS

on the CARE of DRILL STEEL

NOWADAYS it's just common sense to get every bit of service out of a piece of hollow drill steel, whether it's Bethlehem Superior or another make. The following suggestions are probably familiar to most drill-steel users. We publish them as reminders, which if used should prove helpful:

1. Do not use drills with dull bits. Dull bits not only slow down the speed of drilling, but build up fatigue, resulting in premature failure of the drills.

2. Be sure the shank ends of drills are true, and at right angles to the axis of the bar. If shank ends are not cut off square, the hammer will strike on one side of the drill. Excessive strains and vibrations will be set up which will injure both the drill steel and, eventually, the hammer too.

3. Be sure the shank of the drill is full size and that the front head bushing of the hammer is not unduly worn. Excessive play at this point will permit the drill to whip, thus multiplying the stresses in the rod and hastening fatigue failure.

4. Keep the hole through the drill wide open at all times to permit free circulation of air or water.

5. When a drill sticks in the hole and you must strike it to get it loose, be careful not to nick the drill rod. Nicks provide a concentration point for fatigue stresses, and are often the cause of premature failure.

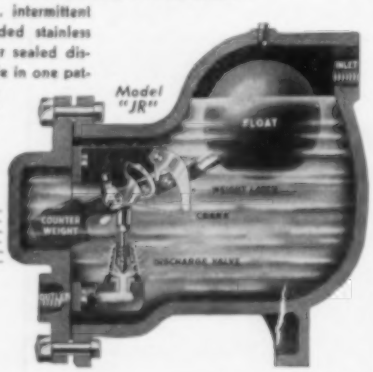
6. Do not leave drill steel where it can be attacked by corrosive mine water or other corrosive agents. The pits resulting from corrosion often lead to premature failure.

BETHLEHEM SUPERIOR HOLLOW DRILL STEEL

BETHLEHEM STEEL

Users Say: "NICHOLSON COMPRESSED AIR TRAPS INCREASE EFFICIENCY OF PNEUMATIC TOOLS BY PROPERLY DRAINING AIR TANKS, RECEIVERS, AFTER COOLERS, ETC."

The Nicholson "JR" Trap is specially designed and constructed to provide long, trouble-free service under continuous operation. Large capacity . . . for pressures up to 200 lbs. . . . intermittent discharge . . . welded stainless steel float . . . water sealed discharge valve . . . made in one pattern size only with either ½", ¾" or 1" inlet and ½" outlet.



Write NOW for Bulletin No. 341

W. H. NICHOLSON & CO., 180 OREGON ST., WILKES-BARRE, PA.

NICHOLSON *Traps*

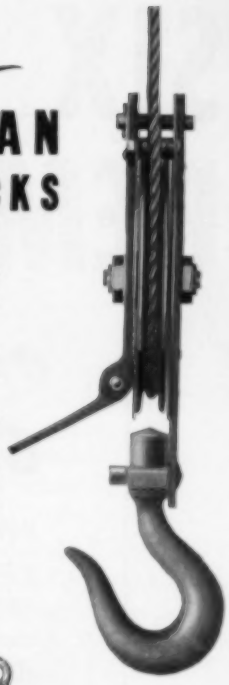
THERMOSTATIC ▼ PISTON AND WEIGHT-OPERATED STEAM GASOLINE AND COMPRESSED AIR TRAPS ▼ ▼ ▼

CONTROL VALVES ▼ FLOATS ▼ MANDRELS ▼ STEAM AND AIR SEPARATORS

Specify AMERICAN WIRE ROPE BLOCKS

Modern design and rugged construction with an unusually high factor of safety recommend the AMERICAN Wire Rope Blocks. They are made in sufficient variety to meet every hoisting requirement in the construction, erection, and industrial fields. Special blocks and standard blocks with special fittings are regularly made for the out-of-the-ordinary conditions.

Catalog 300-BS-1A gives full particulars. Write for your copy.



Oval Shell Snatch Block with swivel hook. The hinged latch is shown in open position.

AMERICAN HOIST AND DERRICK CO.
SAINT PAUL 1, MINN.
Chicago · San Francisco · New York

60 YEARS of Safety 1883-1943 the Genuine CROSBY CLIP

AMERICAN TERRY DERRICK CO., South Kearny, N. J.

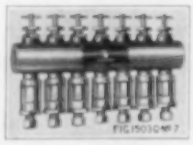
R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.

R.C. PILOT VALVE STRAINER TYPE

R. CONRADER CO.
1207 FRENCH STREET - ERIE, PA.
PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

TO . . . WARTIME INDUSTRIAL PLANTS for *FASTER PRODUCTION*



Multiple Oiler for any number of Feeds

Pressure Sight Flow . . . Bursting Pressure of Glass 400 to 600 lbs

Sight Feed Oiler . . . Clean while oil is running

Sight Flow Indicators Sizes up to 6" inclusive

Get full details on how Nugent Oiling Devices are helping industry, by: (1) Increasing efficiency and life of machine; (2) conserving oil; (3) reducing fire hazard by delivering oil in the proper place and in proper quantities; and (4) by speeding production. Write today.

WM W. NUGENT & CO., INC.
422 N. HERMITAGE AVE., CHICAGO, ILL.

NUGENT LUBRICATION SPECIALTIES

DIVIDIVI TREE

Air Power created by pressure differences in the atmosphere is capable of producing many wonders. The Dividivi trees located in Aruba, Dutch West Indies, attract attention because of their strange and almost fantastic appearance. These Dividivi trees differ from those in other localities because in Aruba they are in the path of the trade winds, whose continuous and uninterrupted breeze has wrought their picturesque shapes.

Many of the miracles in the production of war materials are being accomplished with the aid of air power in a more practical form—Compressed Air and Air Tools. Air Tools are preferred by men and women on production lines because they are powerful, durable, safe, small, and light in weight; hence they can produce more work with less effort.

Ingersoll-Rand has available a complete line of air tools. To supply air for these tools and many other uses, we offer a size and type of air compressor for every job. Our specialists are familiar with all applications and will gladly work with you.

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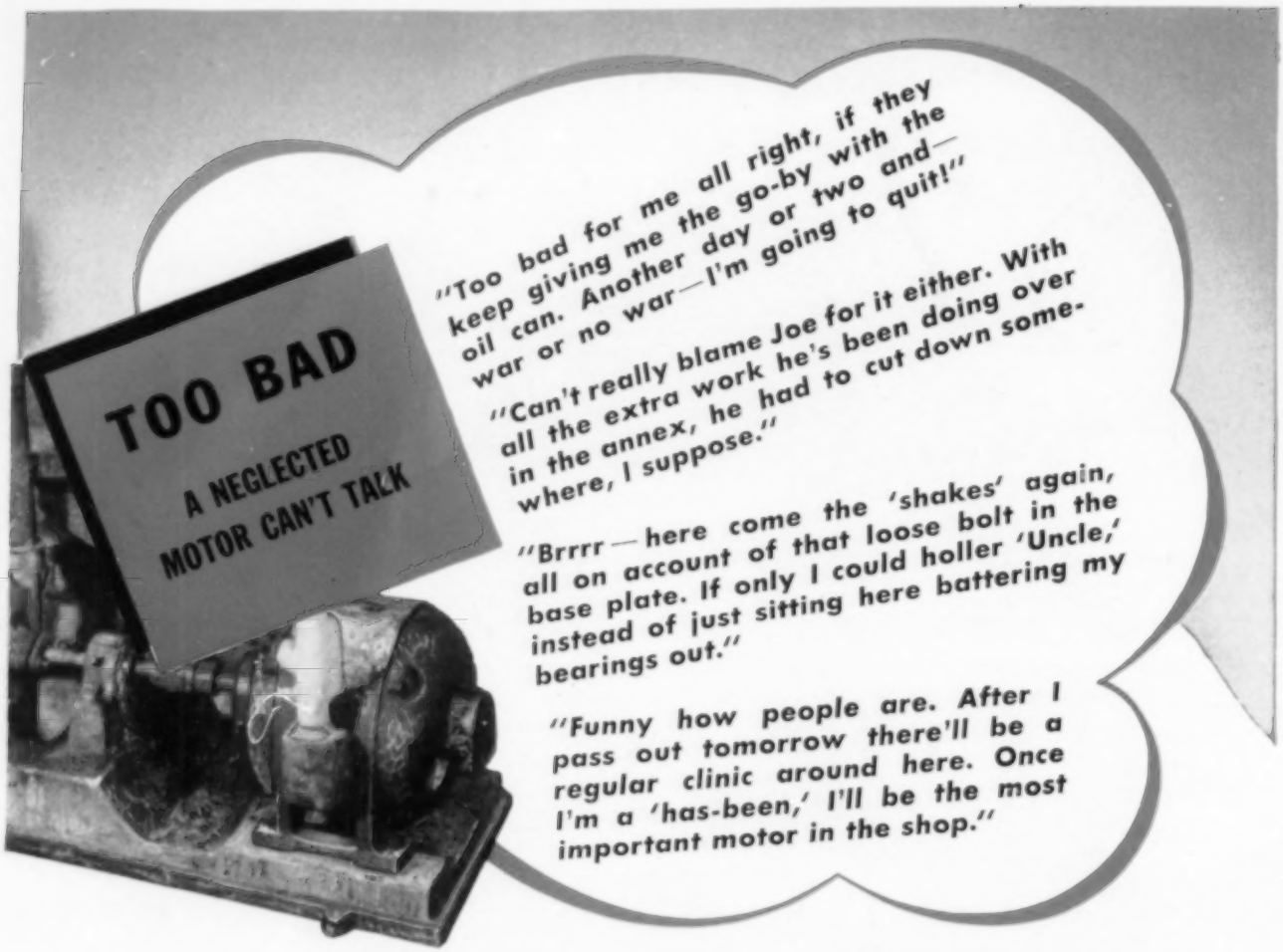
COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES


TOO BAD
A NEGLECTED MOTOR CAN'T TALK
"Too bad for me all right, if they keep giving me the go-by with the oil can. Another day or two and—war or no war—I'm going to quit!"
"Can't really blame Joe for it either. With all the extra work he's been doing over in the annex, he had to cut down somewhere, I suppose."
"Brrrr—here come the 'shakes' again, all on account of that loose bolt in the base plate. If only I could holler 'Uncle,' instead of just sitting here battering my bearings out."
"Funny how people are. After I pass out tomorrow there'll be a regular clinic around here. Once I'm a 'has-been,' I'll be the most important motor in the shop."

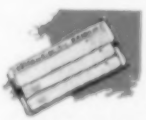
Preventive Care of Motors

. . . IS A MANAGEMENT PROBLEM

HERE'S HOW G.E. CAN HELP YOU SOLVE IT

A regular schedule for oiling, cleaning, and inspection of every motor is half the battle in keeping motors fit.

The G-E booklet "How to Care for Motors" tells what to do and when to do it. You can use it as a basis for issuing definite instructions, and for analyzing the hours of work involved so that your maintenance crews can be adequately staffed. Ask for GEA-2856A.



To get the most out of motors, and to meet new WPB requirements, the required horsepower for every job must be accurately known. On metal-cutting operations, the new G-E MOTORULE is just what you need to determine your requirements. Simple to use, it saves time and saves motor horsepower. Ask for GEL-763.

Free G-E Motor Record Cards (GES-1526A) make it easy to keep a convenient record of the specifications and service history of every motor in your plant.

BUILDER OF TRI-CLAD MOTORS

GENERAL ELECTRIC

General Electric, Sec. AD750-208, Schenectady, N. Y.

Yes, please send me:

- ☐ "How to Care for Motors" (GEA-2856A)
- ☐ G-E MOTORULE (GEL-763)
- ☐ A supply of ..... Motor Record Cards (GES-1526A)

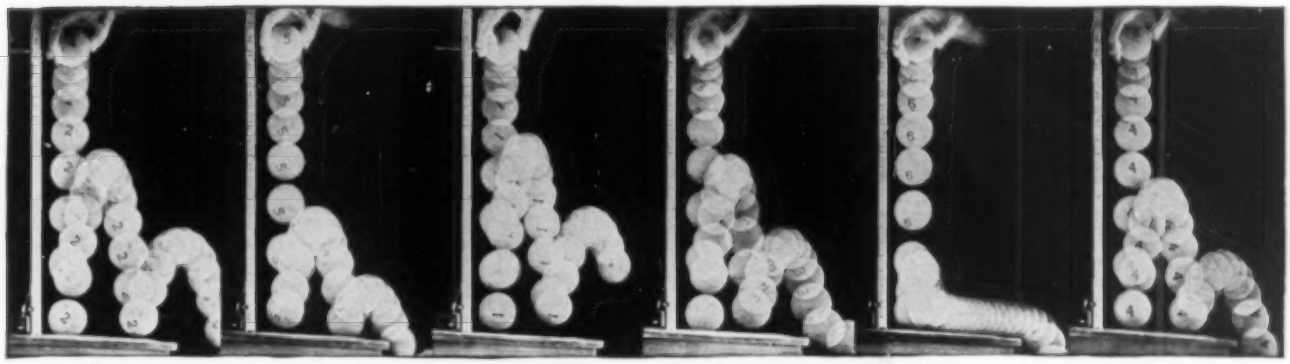
Name .....

Company .....

Address .....

City ..... State .....

BOUNCE, BALLS, BOUNCE!



2 (Synthetic) 5 (Synthetic) 1 (Natural) 3 (Synthetic) 6 (Synthetic) 4 (Synthetic)

SIX SOLID BALLS OF RUBBER caught in the act of bouncing by a high-speed camera that shoots at the speed of 1/6592 of a second. All of them were dropped from exactly the same height...and yet, what a difference there is! One of the balls is made of a compound containing natural rubber. Each of the other five balls contains one of the five major types of synthetic rubber.

Can you pick out which of the balls is made of the rubber used in making Army barrage balloons? Which rubber is being used today for making tires for military and essential civilian cars? Which one is used for bullet-sealing gasoline hose? Which for insulating tape? Which for making lacquer hose? Try your skill. You will find the answers to these questions in the box at the bottom of this page.

SYNTHETIC RUBBER IS NOT JUST ONE NEW KIND OF RUBBER

It is a whole family of new materials each with its own important uses

Bounce the balls as much as you please. One bounces high. One bounces low. One bounces in between. Which one is best? Actually, there is no one "best kind" of rubber for every purpose. Without all of these main types of synthetic and natural rubber, it would be impossible to beat our enemies and bring our victorious men home as swiftly as possible.

The rubber industry, the chemical and petroleum industries, the Government, working as a team, have made this achievement possible. By pooling all their experience with synthetic rubber, their resources, their skill, they have broken the threat of "rubber shortage" the Axis counted on to throw us out of the war. More than that, they have produced types of synthetic rubber that can do special jobs better than they have ever been done before... and for all time declared our independence from any future cut-off of the nation's rubber supply.

That is the true meaning of the synthetic rubber program. We are proud to have contributed our experience and our resources to doing this job...and doing it in record-breaking, history-making time.

What the future holds for synthetic rubber is not yet fully known. Yet this much is certain. When the war is won, the knowledge we are gaining every day through the use of all these synthetic rubbers, alone and with natural rubber, will make peacetime products... whether tires for your car, belts for your factory, waterproof footwear for your children, or gasoline hose for your service station...better and more serviceable than they have ever been before.

THEY MAY LOOK LIKE "SIX OF A KIND" BUT HERE ARE THE ANSWERS TO THE WAR JOBS EACH ONE CAN DO

1. This ball was made with natural rubber...today used in limited quantities in combination with synthetics because of our small reserve stock.

2. Used for tires, conveyor belts, fire hose and many other products. It is most like natural rubber and can be quickly and efficiently processed.

3. Used for making solvent and lacquer hose and other products where the utmost resistance to solvents is needed...better than natural rubber for these purposes.

4. Used for making bullet-sealing fuel hose for planes and for other uses where high resistance to aromatic fuels is essential.

5. Used for coating barrage balloons, tank linings, packings, acid hose, wires and cables. This type does not support combustion and is highly resistant to sunlight and chemicals.

6. Used for insulating tape, molded parts. It is soft, pliable and odorless.

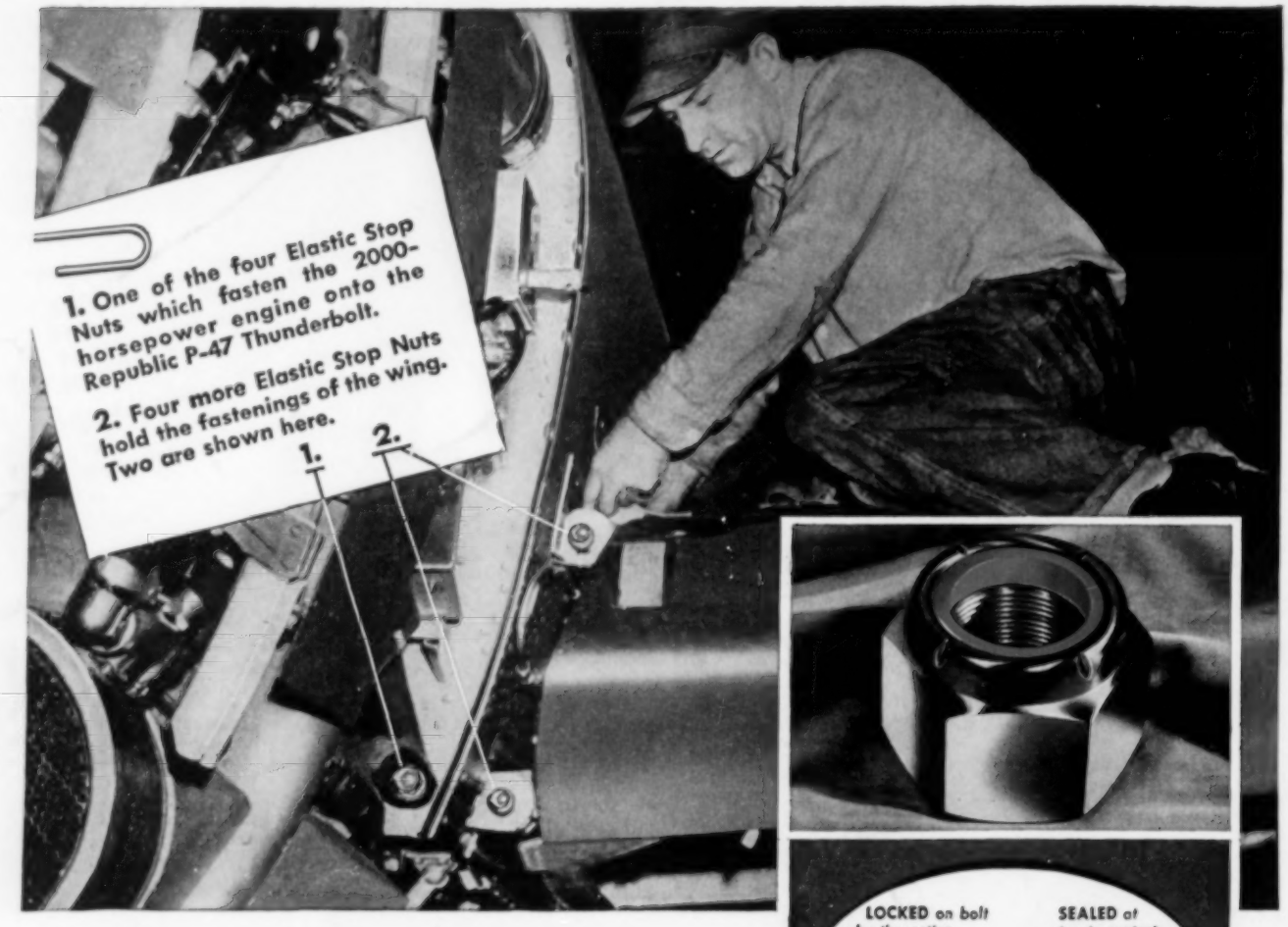
Listen to United States Rubber Company program, featuring New York Philharmonic Symphony Orchestra, Carl Van Doren, and a guest star, broadcast over Columbia network every Sunday afternoon 3:00 to 4:30 P. M. Eastern War Time

1230 Sixth Avenue • Rockefeller Center • New York 20, N. Y.

THE NATION'S BIGGEST STOCK PILE OF RUBBER IS STILL THE RUBBER ON OUR CARS AND TRUCKS...CONSERVE YOUR TIRES!

In Canada: Dominion Rubber Company, Ltd.

UNITED STATES RUBBER COMPANY


1. One of the four Elastic Stop Nuts which fasten the 2000-horsepower engine onto the Republic P-47 Thunderbolt.
2. Four more Elastic Stop Nuts hold the fastenings of the wing. Two are shown here.
1.
2.

LOCKED on bolt by the action of the gripping red collar
SEALED at top to protect working threads from corrosion
PLASTIC collar cushions vibration—nut can't shiver loose
FITS any standard bolt. Made in all sizes and types

You've gotta hang on when you say "Giddap" to 2,000 horses

When the pilot of a Republic P-47 pours on the soup, 2,000 surging, throbbing horsepower yank him into the high blue heavens.

When he climbs straight up he is literally hanging on his prop and engine.

And those tons of plane, man and armament hold onto that engine with just four Elastic Stop Nuts.

This is the kind of job that has given Elastic Stop Nuts the reputation of having revolutionized modern aircraft construction. It's the reason you find over 12,000 of them on the P-47 and as many as 50,000 on some types of bombers.

It's all because these nuts hold fast — without auxiliary locking devices. They're applied like ordinary nuts. They can be removed and replaced time and again without losing locking effectiveness. They stay put, and nothing, even violent vibration, shakes them loose.

It's done by the red elastic collar in the top. This collar clings tightly around the bolt threads. It absorbs and cushions vibration from every direction. The nut can't shiver loose — can't turn.

Postwar progress will present countless fastening problems which these nuts will solve. Perhaps you already are studying such problems. If so, let us know about them. Our engineers will be very glad to help work out a solution and show you how an Elastic Stop Nut will provide a safer, surer, trouble-free fastening.

ELASTIC STOP NUTS

Lock fast to make things last

ESNA

BACK THE ATTACK . . . BUY WAR BONDS

ELASTIC STOP NUT CORPORATION OF AMERICA

UNION, NEW JERSEY AND LINCOLN, NEBRASKA